INSTRUCTION MANUAL

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Gertsch*

MODEL PCR-1

VLF PHASE COMPARISON RECEIVER

Gertsch*
EMPIRE*
Sensitive Research*
Panoramic*
SINGER

*A Trademark of THE SINGER COMPANY

Precision electrical and electronic instruments for measurement

THE SINGER COMPANY • METRICS DIVISION

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2. Serial Number
3. Description of trouble(2)
4. Test instruments used
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7. Has maintenance action been previously requested?
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(2) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken, and any other relevant data.

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Figure 1-1. Model PCR-1 VLF Phase Comparison Receiver

SECTION I

GENERAL DESCRIPTION

1-1. PURPOSE.

1-2. The Gertsch Model PCR-1 Phase Comparison Receiver compares precision frequency standards with very low frequency (VLF) transmissions. Because phase divided by time equals frequency, the rate of phase change between the two input signals indicates the fractional error of the local standard as referred to the VLF signal. A built-in strip-chart recorder indicates the rate of phase change.

1-3. ACCURACY CONSIDERATIONS.

1-4. The receiver is intended for use with local frequency standards which are accurate to 1 part in 10^{-6} or better. By utilizing the propagation stability of low frequency waves and the accuracy of VLF standard frequency broadcasts, comparison accuracies of 1 part in 10^{-9} can be obtained in a fraction of an hour, 5 parts in 10^{-10} in an hour, and higher accuracies for longer periods. For a comparison between the accuracies obtainable with high frequency and low frequency broadcasts, refer to figure 1-2.

1-5. DESCRIPTION.

1-6. The incoming VLF signal is converted to 100 KC through frequency synthesizing circuitry and the local standard signal is converted, if required, to 100 KC by frequency division circuitry. The local standard signal is then phase-locked to the VLF signal through an electrical-mechanical phase shifter and a two speed servo system. In the slow speed mode, the system will track errors up to 1 part in 10^{-8} and the effect of noise as related incoming signal strength is decreased. In the high speed mode, the system will track errors up to 1 part in 10^{-6}. Speed may be controlled automatically or manually. When automatic speed control is used, the system shifts to the high speed mode during periods of rapid change and returns to the slow speed mode when conditions stabilize.

1-7. Up to four frequencies in the 10 KC to 100 KC range may be selected through a front panel selector switch. Since operating frequencies are determined by plug-in modules, additional frequencies can be selected by exchanging modules. Since all frequency determining components are included in the plug-in modules and are pretuned, no tuning is required.

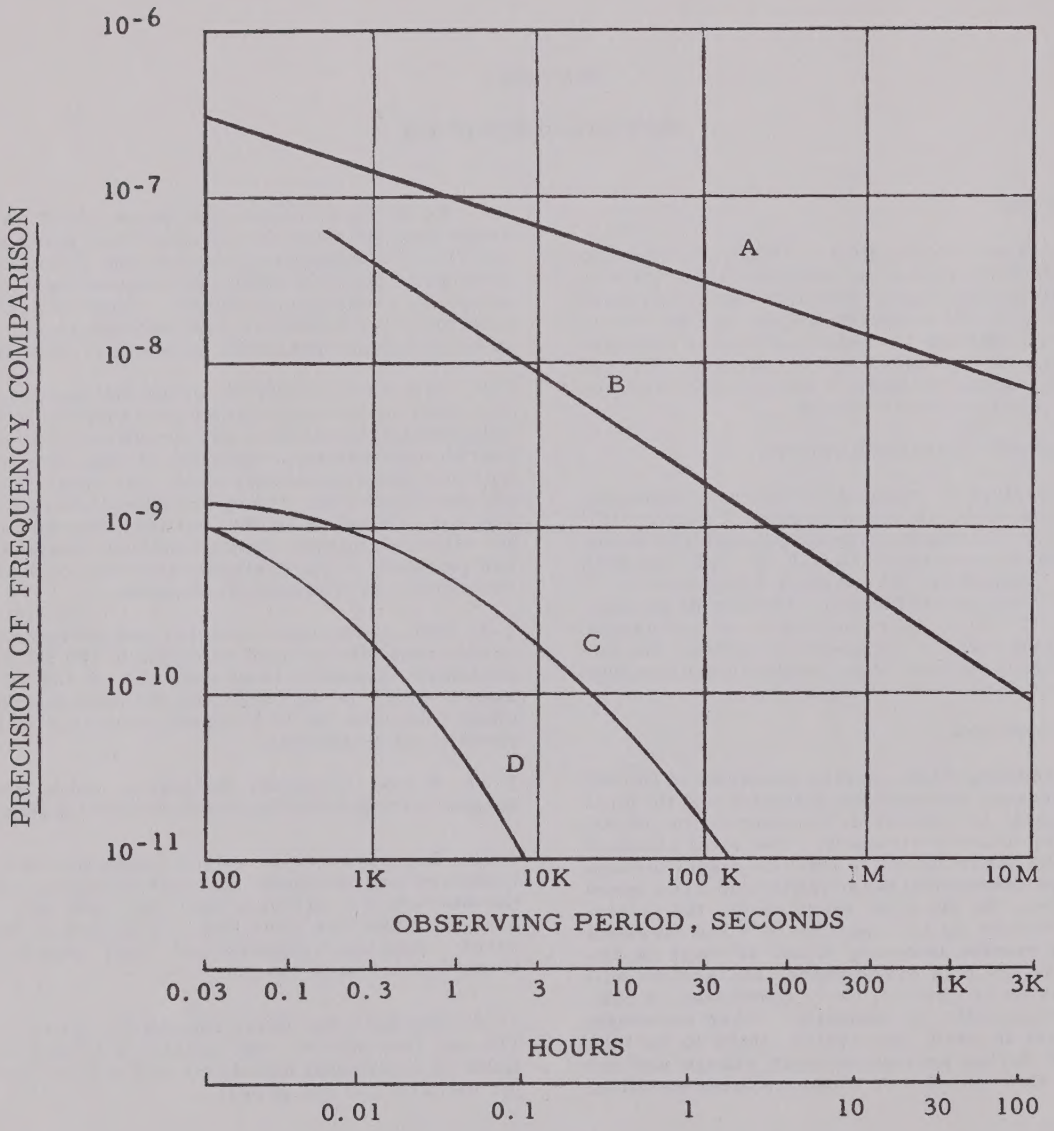
1-8. Due to the sensitivity of the RF section and the flexibility of the input circuit the problems of antenna selection and installation are simplified. The receiver may be used with loop, vertical, or long wire antennas without requiring external tuning circuits. For multiple band operation where directional characteristics are not critical, a 20 foot vertical should suffice for the stronger signals. Remote antenna control circuits are included for automatically selecting or positioning the antenna as frequency is changed.

1-9. The comparison circuitry and strip-chart recorder may also be used to compare 100 KC or 1 MC oscillators against a local standard. A 100 KC output signal, which is derived from the local standard and phase locked to the VLF signal, may also be used to check local oscillators.

1-10. A beat frequency oscillator and a concealed speaker are included for audio monitoring purposes.

1-11. The receiver is an all transistorized, self-contained unit designed for rack mounting or, with the addition of a carrying case, for field use. Operating controls are identified and located on the front panel. Auxiliary controls and input connectors are located on the back panel.

1-12. Normally the unit is shipped for operation from 115 vac line power. By simple re-arrangement of links on a terminal board, the unit may be converted for use with 230 vac power.



Line A: 100 sec. samples, 1 sample/day at noon, 10 mc.
Line B: 24 hr. avg. each day, time pulses, 10 mc.
Line C: Phase comparison, 20 kc.
Line D: Phase comparison, 60 kc.

Figure 1-2. HF and VLF Frequency Comparison Precision for Path Length of 2000 KM to 8000 KM

TABLE 1. SPECIFICATIONS

Frequency Range	10 KC to 100 KC at 100 cps increments
Sensitivity	0.1 microvolt into 50 ohms for stable, phase-locked tracking
Bandwidth:	
RF	Approximately 1% of input frequency (may be increased on special order)
Pre-detection	10 cps
Servo	0.2 or 0.002 cps selected manually or automatically
Phase Stability	Better than 0.5 microseconds rms
Standard Input	100 KC or 1 MC, 0.5 to 5.0 vrms into 10,000 ohms
Comparison Input	100 KC or 1 MC, 0.5 to 5.0 vrms
VLF Signal Output	Approximately 0.3 vrms, 10,000 ohms output impedance
Standard Frequency Output	100 KC at approximately 1 vrms into 1000 ohms
Carrier Level Output	Will drive a 1 ma, 1000 ohm load. Time constant is approximately 20 seconds
Chart Recorder:	
Type	Pressure sensitive paper
Speed	1, 2, 3.6 (1 inch per 1000 seconds), or 4 inches per hour
Input Power	115/230 vac, 60 cps, 60 va
Size	Standard 19 inch rack width, 7 inches high, 14 inches deep

SECTION II

INSTALLATION

2-1. GENERAL.

2-2. The only installation procedures required are the installation of the antenna and connection to a power source. Prior to installation, remove the top dust cover and make certain that all packing material is removed from the case. Check that protective material is removed from the pens of the chart recorder.

2-3. ANTENNA CONSIDERATIONS.

2-4. For optimum results, the incoming VLF signal strength should be sufficient to cause 0 to 10 db deflection of the RELATIVE SIGNAL LEVEL meter. The receiver will operate satisfactorily as long as an on-scale indication is obtained. Excessive signals may be reduced through the use of the RF ATTEN (DB) control (up to 60 db attenuation).

2-5. Any antenna which will provide an on-scale indication at all supplied frequencies will suffice. If a vertical or long wire antenna is used, connect the antenna to the HIGH IMPEDANCE connector located on the back of the unit and tune each channel as outlined in paragraph 2-6. Make certain that the chassis of the unit is connected to an earth ground. If a loop antenna is used, connect the antenna to the 50 ohm connector located on the back of the unit. If a number of antennas are used or if the antenna is positioned, refer to paragraph 2-8.

2-6. HIGH IMPEDANCE ANTENNA TUNING.

2-7. To tune a high impedance antenna, proceed as follows:

a. Operate the receiver as outlined in paragraph 3-4.

b. Turn the ANT TUNING control (front panel) to approximately the midpoint of its range.

c. Adjust the ANTENNA TUNING control (back panel) for the applicable channel for maximum indication on the RELATIVE SIGNAL LEVEL meter.

d. Repeat procedure for each channel.

NOTE

The built-in antenna tuner is designed for use with most standard vertical or long wire antennas. For some installations, the tuning range may not be sufficient and an external tuning device or control will be required.

2-8. REMOTE ANTENNA CONTROL.

2-9. The control circuitry consists of one section of the FREQUENCY selector switch and the REMOTE ANTENNA CONTROL connector located on the back of the unit (see figure 2-1). When the switch is rotated, continuity is made between a common pin and the pin for the applicable channel. An extra switch section and spare connector pins are included to provide additional flexibility in the wiring of an antenna control.

2-10. POWER CONVERSION.

2-11. To convert the unit from 115 vac to 230 vac power, proceed as follows:

a. Remove the bottom dust cover from the unit and locate terminal board TB1. The terminal board is located on the back of the unit, near the inlet point of the power cord.

b. Rearrange the links as shown in figure 2-2.

c. Replace the 1 amp fuses, F1 and F2, with 0.5 amp fuses.

NOTE

The unit is designed for 60 cps power. When 50 cps power is used, the servo motor B102 must be replaced with a 50 cps unit. The chart drive motor will operate at 5/6 of its normal speed and therefore a 5/6 correction factor must be applied to the chart recordings.

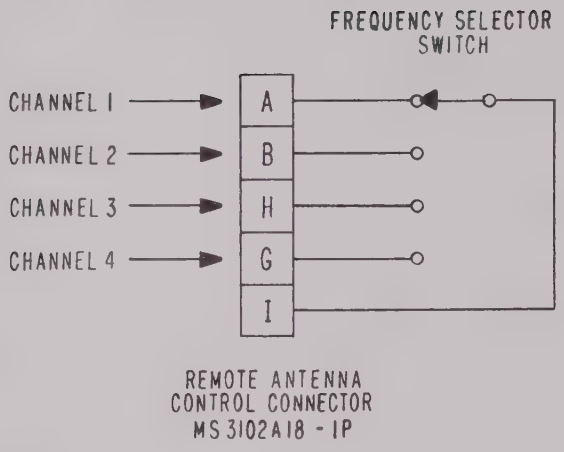


Figure 2-1. Remote Antenna Control Circuit

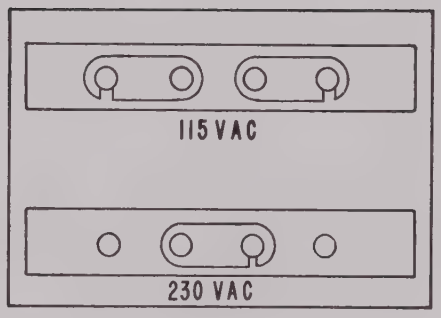


Figure 2-2. VAC Power Conversion

SECTION III

OPERATING INSTRUCTIONS

3-1. GENERAL.

3-2. Paragraph 3-3 includes a normal procedure for comparing a local standard to a VLF signal and is followed by operating notes, interpretation of results, and use of auxiliary functions. Refer to Table 2 for the function of the various operating controls and indicators. Refer to Section IX for examples of comparison recordings.

3-3. STANDARD TO VLF COMPARISON.

3-4. To compare a local standard to a signal from a frequency-stabilized VLF station, proceed as follows:

a. Make certain the power cord is connected to a power source.

b. Make certain that an antenna is connected to either the HIGH IMPEDANCE or 50 OHM antenna connector.

c. Turn the MODE switch (back panel) to the RECEIVER position.

d. Turn the SERVO LOCKOUT switch (back panel) to the OFF position.

e. Connect the local standard to the STANDARD INPUT connector (back panel). Make certain that the standard is warmed up and that the output level is between 0.5 and 5 vrms.

f. Turn FREQUENCY selector switch to the selected station. Refer to Table 3 for a partial listing of frequency stabilized, VLF stations.

g. Turn SERVO switch to the FAST position.

h. Turn POWER switch on and allow a warm up of approximately one minute.

i. Turn AUDIO control clockwise from the OFF position and adjust to the desired level.

j. If a high impedance antenna is used, adjust ANT TUNING control for maximum audio output or for a maximum indication on the RELATIVE SIGNAL LEVEL meter. Allow at least 40 seconds for the system to stabilize and recheck tuning.

k. For optimum performance, adjust the ANTEN (DB) control until the RELATIVE SIGNAL LEVEL meter indicates between -10 db and 10 db. Allow at least 40 seconds for the system to stabilize and recheck the setting.

l. Select chart speed to accommodate the anticipated error. The greater the anticipated error, the faster the speed should be. Depress the speed control lever to release the drive mechanism from a detented position, rotate the lever to the selected speed position, and release the lever. If the lever does not lock into the new position, rotate the lever up or down until it locks into position.

m. Turn the chart drive switch on.

3-5. OPERATING NOTES.

3-6. SERVO LOCKOUT SWITCH. When the switch is turned to the AUTO position, the servo system is locked out whenever the VLF signal drops below the level required for stabilized, phase lock operation. When an error comparison is required during periods of marginal reception, the switch may be turned to the OFF position allowing the servo system to operate at all times. Since the system will not necessarily track under these conditions, any results should be used with extreme caution. The comparison recording may be extremely erratic, requiring a very careful analysis of the recording.

3-7. SERVO SWITCH. During the warm-up period, periods of rapid change, or if a large error is anticipated, the SERVO switch should be turned to the FAST position to provide a smooth, even readout curve. When long term records of a stable, accurate standard are desired, the switch may be turned to the AUTO position. In the AUTO position, the servo system speed will be automatically selected to suit the circumstances. When maximum selectivity at all times is desired, the switch should be turned to the SLOW position. However, in the slow speed mode the system is not capable of tracking rapid changes or large errors.

3-8. HIGH SPEED MARKER. Whenever the system is operating in the high speed mode, a straight line marker will appear on the right hand margin of the chart. The marker will not appear during periods of low speed operation. The appearance of a marker may be used as an indication of large error or a period of rapid change.

3-9. SIGNAL LEVEL MARKER. Whenever the incoming VLF signal drops below the level required for stable operation, a straight line marker will appear on the left hand margin of the chart. Any readings obtained while the marker is present should be used only with caution.

3-10. AGC TIME CONSTANT. To account for the various duty cycles of the VLF stations, the AGC circuit has a time constant of approximately 20 seconds. With the long time constant, the RELATIVE SIGNAL LEVEL meter reacts slowly to changes in input signal level and tends to over compensate. During the period of adjustment, the audio output will change radically and then adjust to the new signal level. Allow at least 40 seconds for system stabilization after any change in signal level.

3-11. SELECTION OF VLF STATION. The optimum results are obtained when the path between the transmitter and receiver is all darkness or all daylight. Although VLF reception is extremely stable, the diurnal shift will cause phase shifts in the VLF signal. Any phase shift will appear as apparent error in the local standard. When long term records are obtained, the recordings should be studied for possible errors resulting from phase shift.

3-12. MICROSECONDS COUNTER. The MICROSECOND counter provides a total, cumulative record of

phase correction. If the counter is to be used to obtain the phase correction during a specific time period, the time and indication must be noted at the beginning and end of the period. The total correction during the period can be obtained by simple subtraction. The counter is calibrated so that the last two digits indicate 00 when recording pins are at the margins. The reading increases when the pin moves from left to right.

3-13. PHASE DETECTOR OUTPUT. The dc output of the detector, as supplied to the PHASE DETECTOR OUTPUT connector, may be used to check errors larger than the tracking range of the servo system as follows:

a. Connect oscilloscope or counter to the PHASE DETECTOR OUTPUT connector.

b. Operate unit as outlined in paragraph 3-4 or 3-19.

c. Turn SERVO switch to the OFF position.

d. The dc output of the phase detector will vary at the rate of the difference in frequency between the two inputs to the phase detector. When the difference frequency is less than 0.1 cps, the servo system will track the error in the fast mode.

3-14. INTERPRETATION OF RESULTS.

3-15. The chart recorder indicates the amount of phase correction applied to the local standard in order to maintain the phase locked condition. A straight vertical line at any point on the chart indicates that no correction is required. If the line moves to the right the frequency of the local standard is above 100 KC (or 1 MC). Movement to the left indicates that the local standard is below frequency. The greater the error, the nearer the recorder line approaches a straight horizontal line.

3-16. The fractional error curves furnished with your unit and reproduced in figures 3-1 through 3-4 may be used to convert the chart recording to local standard error. When the bottom of the curve chart is aligned with a horizontal line of the chart, the error curve which coincides with the chart recording curve indicates the local standard error.

3-17. The fractional error may be calculated as follows:

a. Measure the total correction required during a given time period. The horizontal chart scale includes 50 divisions or 2 microseconds of phase time correction per division. Convert the correction to seconds by multiplying the correction by 10^{-6}.

b. Determine the real time of the comparison period. Since the major divisions of the chart scale equal one inch, the real time can be determined by counting scale divisions and dividing by chart speed. Convert real time to seconds. (Time in hours by 3600.)

c. Divide phase time by real time to obtain the fractional error.

EXAMPLE: The total lateral movement is 1-1/2 scale divisions (3 microseconds) on one inch of chart and the chart speed is set at 1 inch per hour.

$$\frac{3 \text{ (microseconds)} \times 10^{-6}}{\frac{1 \text{ inch}}{1 \text{ inch per hour}} \times 3600} = 0.83 \times 10^{-9}$$

NOTE

In the 3.6 per hour chart speed, the chart travels at a rate of 1000 seconds per inch.

3-18. AUXILIARY FUNCTIONS.

3-19. LOCAL OSCILLATOR TO STANDARD COMPARISONS. To compare a local oscillator to a local standard, proceed as follows:

a. Turn the MODE switch, located on the back panel, to the COMPARISON position.

b. Turn the SERVO switch to the FAST position.

c. Make certain that the power cord is connected to a power source.

d. Connect the local standard to the STANDARD INPUT connector. Make certain that the local standard is warmed up and that the output level is between 0.5 and 5 vrms.

e. Connect the local oscillator to the COMPARISON INPUT connector. Make certain that the local oscillator is warmed up and that the output level is between 0.5 and 5 vrms.

f. Turn POWER switch on and allow approximately 1 minute warm up.

g. Select chart speed with the speed control lever.

h. Turn chart drive on-off switch to the ON position.

i. Refer to paragraph 3-13 for interpretation of results. When the signal to the COMPARE INPUT connector is tuned to exactly the same frequency as the signal to the STANDARD INPUT connector, the chart indication is a straight vertical line.

NOTE

When the frequency of the COMPARE INPUT signal is high, the chart line moves to the left. The line moves to right when the frequency is low.

3-20. 100 KC OUTPUT SIGNAL. The 100 KC output signal from the receiver may be used for external comparisons and as a base for digital timing systems but the limitations on the use must be recognized. Over a longer period of time, the average 100 KC output signal is extremely accurate. At any given time, the signal is subject to variations due to the inherent nature of the servo system and to variations in the VLF signal. Any time lag in the phase lock procedure and any servo system hunt will result in short-term errors in the output signal.

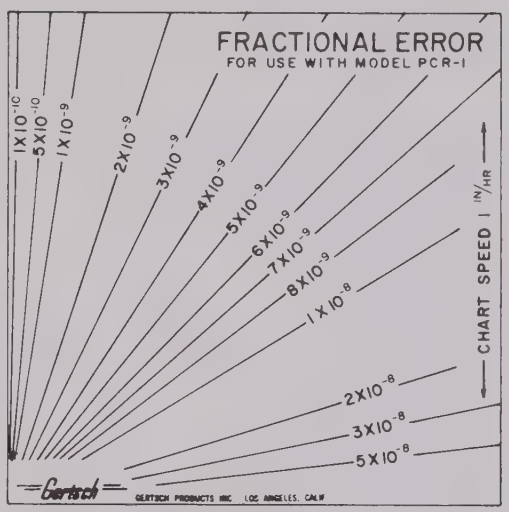


Figure 3-1. Fractional Error Curve for chart speed of one inch per hour.

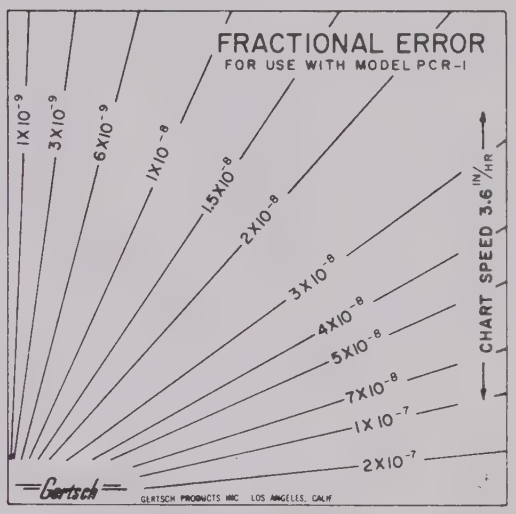


Figure 3-3. Fractional Error Curve for chart speed of 3.6 inches per hour.

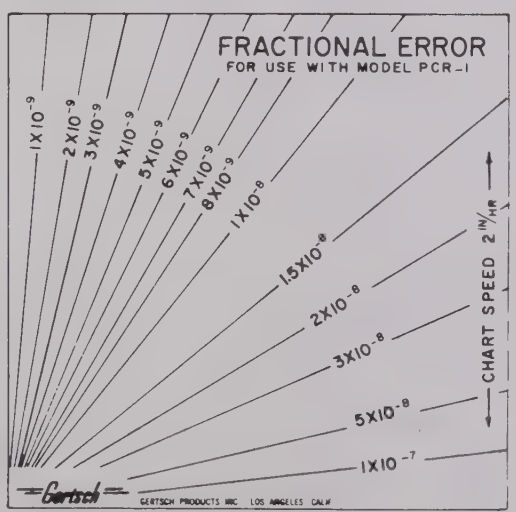


Figure 3-2. Fractional Error Curve for chart speed of two inches per curve.

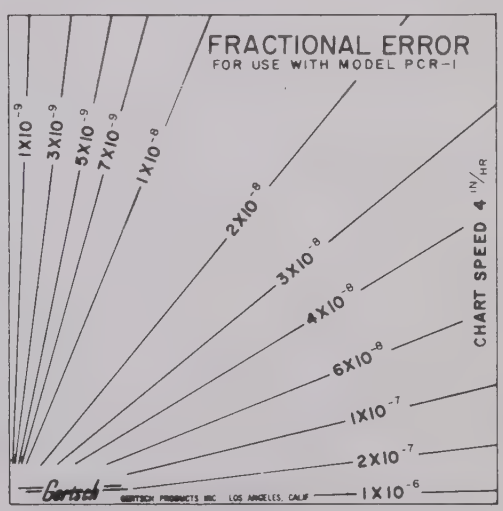


Figure 3-4. Fractional Error Curve for chart speed of four inches per hour.

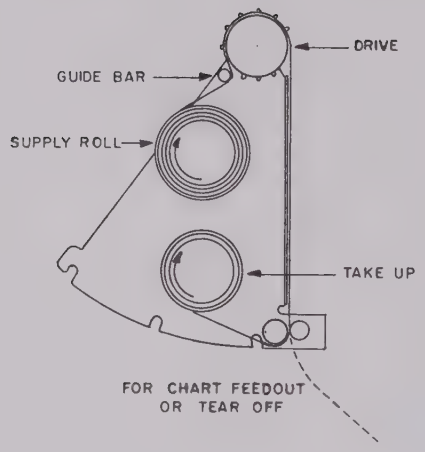


Figure 3-5. Chart Paper Loading Diagram

d. Thread the paper under the guide bar.

e. Insert the chart roll between the supply roll paper hubs.

f. Bring the paper over the top of the drive drum and engage the paper drive holes with the drum sprockets.

g. Pull the paper across the face of the magazine and feed through the slot at the bottom of the viewing surface. Rotate the drive gear to feed the paper through the slot.

h. If the chart is to be fed out of the unit, the magazine may be reinstalled in the unit. The paper will feed out through the bottom of the unit and may be torn off as required. Depress the chart speed lever to release the gears before pulling the paper through.

i. To store the chart in the recorder, insert an empty spool between the take up paper hubs. Be sure that the slot in the spool mates with the drive stud of the fixed hub.

j. Bring the end of the paper up to the take up spool and fasten in place with tape. Rotate the drive gear until a turn or two of paper is on the take up spool. Check for proper chart tracking and reinstall the magazine in the unit. After the magazine is installed, depress the chart speed lever and rotate the magazine drive gear to remove any slack in the paper.

3-23. ADDING OR REPLACING A CHANNEL.

3-24. Adding or replacing a channel is accomplished by adding or replacing an RF plug-in module as follows:

a. Remove the top dust cover and pull the module to be replaced from the unit.

b. Remove the applicable frequency button from the front panel and install in the front of module to be replaced.

c. Remove the frequency button from the new module and install in the applicable button hole of the front panel.

d. Install the new module in the unit and replace the top dust cover.

e. Check local oscillator frequency as outlined in Section VI.

f. If a high impedance antenna is used, tune the antenna as outlined in paragraph 2-6.

TABLE 2. FUNCTION OF OPERATING CONTROLS, INDICATORS, AND CONNECTORS

PANEL MARKING	TYPE OF CONTROL	FUNCTION
Relative Signal Level	Meter	Indicates approximate level of incoming RF signal (AGC voltage).
RF ATTen (DB)	Six position rotary switch	Controls incoming RF signal level by applying attenuation.
Signal Level	BNC Connector	Supplies RF signal level information for external recording.
Frequency	Four position rotary switch	Selects one of four VLF stations. When an antenna control is connected, also selects or positions antenna.
Ant Tuning	Variable resistor	Fine control for tuning a high impedance antenna.
Power	Indicator lamp	Lights to indicate application of power.
	Toggle switch	Power on-off switch.
Servo	Four position rotary switch	In the OFF position, turns phase lock system off.
		In the SLOW position, sets phase lock system to operate in the slow or narrow bandwidth mode.
		In the AUTO position, sets phase lock system to automatically select slow or fast mode.
		In the FAST position, sets phase lock system to operate in the fast or wide bandwidth mode.
Audio Gain	Variable resistor and on-off switch	On-off switch and level control for audio monitoring circuit.
RF Output	BNC Connector	Supplies amplified RF signal for external uses.
Microseconds	Digital Counter	Accumulates and display phase correction in microseconds of phase time.
	Chart Recorder	Displays phase correction in microseconds of phase time.
Chart Drive	Speed Control Lever	Selects one of four chart recording speeds.
	Toggle switch	On-off switch for chart drive (also lifts marker pens when turned off).
NOTE: The following controls and connectors are located on the back panel.		
1A	Fuses (2)	Input power fuses.
Servo Lockout	Two position rotary switch	In the AUTO position, allows the AGC system to lock out the servo system when the VLF signal level drops below a predetermined level.
		In the OFF position, disengages the AGC lockout feature.
Mode	Two position rotary switch	In the RECEIVER position, switches circuity to compare a local standard to a VLF signal.
		In the COMPARE position, switches circuitry to compare a local oscillator to a local standard.
100 KC Output	BNC Connector	Supplies phase-locked 100 KC signal for external uses.
Compare Input	BNC Connector	Input connector for a local oscillator.

TABLE 2. FUNCTION OF OPERATING CONTROLS, INDICATORS, AND CONNECTORS (Continued)

PANEL MARKING	TYPE OF CONTROL	FUNCTION
Standard Input	BNC Connector	Input connector for a local standard.
Phase Detector Output	BNC Connector	Supplies phase detector output for checking errors outside of the servo system tracking range.
Remote Antenna Control	Connector	Connection point for the antenna control circuit associated with the FREQUENCY switch.
High Impedance Antenna	BNC Connector	Input connector for a vertical or long wire antenna.
60 Ohm Antenna	BNC Connector	Input connector for a loop antenna.

TABLE 3. FREQUENCY STABILIZED VERY LOW FREQUENCY STATIONS

CALL SIGN	LOCATION	FREQUENCY	RADIATED POWER	DB/1 KW	DB/UV PER METER
GBR	Rugby, England	16 KC	40 KW	16	66
MSF	Rugby, England	60 KC	--	---	--
NAA	Cutler, Maine	14.7 KC	2000 KW	33	83
NBA	Balboa, Panama	18 KC	30 KW	15	65
NPG/NLK	Jim Creek, Washington	18.6 KC	250 KW	24	74
NPM	Lualualei, Hawaii	19.8 KC	100 KW	20	70
NSS	Annapolis, Maryland	22.3 KC	100 KW	20	70
WWVB	Boulder, Colorado	60 KC	7 KW	8.5	58
WWVL	Boudler, Colorado	20 KC	1 KW	0	50

NOTES:

1 KW radiated power = 50 db/uv per meter.

3 db attenuation per 1000 miles (over sea).

6 db attenuation per 1000 miles (over land).

NOTE: NAA, NBA, NPG/NLK, NPM and NSS ARE OPERATED BY THE US NAVY AND MAY CHANGE FREQUENCIES WITHOUT NOTICE.

SECTION IV

THEORY OF OPERATION

4-1. GENERAL THEORY. (See figure 4-1.)

4-2. The VLF signal is amplified in the RF plug-in module and converted to a 100 KC signal in the doubler-mixer assembly. This 100 KC signal is applied to one side of the two phase detectors in the phase detector assembly and functions as the reference signal.

4-3. The 1 MC or 100 KC signal from the local standard is converted to two 100 KC signals (0° and 90° out-of-phase) which are applied to the resolver. The 100 KC signal out of the resolver is applied to the other side of the phase detectors and functions as the detector signal.

4-4. When the two signals in the servo phase detector are exactly 90° out-of-phase, the output of the detector is zero and the servo system is at null. Any difference in frequency between the two signals results in a phase shift. The phase shift produces a dc output from the detector which is converted to a 60 cps signal in the servo amplifier assembly. The 60 cps signal is applied to the control windings of the servo motor and operates the motor.

4-5. If the detector signal frequency is below the reference signal frequency, the output of the phase detector is positive. The positive voltage is converted to a control winding voltage which is 180° out-of-phase with the motor winding voltage and the servo motor rotates in a counterclockwise direction. If the detector signal frequency is high, the phase detector output is negative, the control winding voltage is inphase, and the servo motor rotates clockwise.

4-6. The servo motor is geared to the resolver which operates as an electro-mechanical phase shifter. As the servo motor rotates, the resolver applies a phase shift to the 100 KC detector signal. Each revolution of the resolver applies a phase shift equivalent to a gain or loss of one cycle. When the applied phase shift equals the difference in frequency, the servo system returns to null.

4-7. The resolver, in turn, is geared to the chart recorder and the microseconds counters. Both the recorder and counter are calibrated to display resolver rotation in microseconds of phase time. Any correction required to maintain servo system null or phase lock is therefore displayed. The direction of change on the recorder indicates whether the local standard is high or low in frequency. The counter adds to indicate that the local standard is low and subtracts to indicate that the local standard is high.

4-8. AUTOMATIC SERVO SYSTEM SPEED CONTROL. The amplitude of the signal from the servo phase detector is related to the phase difference between the two signals. At 90° the output is minimum and at 0° (or 180°) the output is maximum. If a correction greater than 0.002 cycles per second is required, the servo system cannot track the change in the slow speed mode. The phase difference between the signals increases, the dc output of the phase detector increases, and the amplitude of the speed shift signal to the shim and lockout assembly increases. When the speed shift signal reaches a predetermined level, the shift and lockout assembly releases a solenoid which in turn reduces the servo motor-to-resolver gear ratio by a factor of 100. When the phase error has been corrected, the system returns to the slow speed mode. System speed may also be controlled manually.

4-9. AGC SYSTEM. The AGC phase detector operates in the same manner as the servo phase detector except that a 90° phase shift is introduced into the detector signal. Therefore the output of the AGC phase detector is maximum when the servo system is at null. The amplitude of the signal is also directly related to incoming VLF signal level. The dc output of the phase detector is converted to an ac voltage, amplified, and reconverted to a dc voltage in the AGC amplifier assembly. The output of AGC amplifier is a minus dc voltage whose amplitude is directly related to incoming VLF signal level. This output is applied to the AGC stage of the RF plug-in module and the RELATIVE SIGNAL LEVEL meter.

4-10. When the servo system is off null, the AGC phase detector output decreases regardless of incoming VLF signal level. To maintain an AGC voltage consistent with signal level, an ac output of the servo amplifier assembly is added to the ac portion of the AGC voltage.

4-11. The AGC voltage is also used to stop operation of the servo motor if the VLF signal drops below a predetermined level while the servo system is in the slow speed mode. (The drop in AGC voltage during high speed operation is a result of phase shift and is not necessarily related to signal strength.) The amplitude drop in the ac lockout signal to the shift and lockout assembly allows a relay to operate and cut off power to the servo motor.

4-12. LOCAL OSCILLATOR. The phase locked oscillator assembly provides the mixer frequency for converting the VLF signal to 100 KC. The oscillator is locked to frequency by a signal from the resolver. The output signal of the resolver is converted to a 200 cycle signal through a series of divider circuits and applied to a blocking oscillator. The output of the blocking oscillator locks the local oscillator to frequency.

4-13. AUDIO MONITORING SYSTEM. The 100 KC reference signal is mixed with a beat frequency oscillator to produce an audio tone. The tone is amplified and applied to loudspeaker LS101.

4-14. COMPARISON INPUT SIGNAL. When the compare-receive switch S3 is turned to the compare position, the signal from a local oscillator is converted to 100 KC and functions as the 100 KC reference voltage. The VLF circuitry is switched out of the system for this application.

4-15. DETAILED THEORY.

4-16. ANTENNA CIRCUITS. (See figure 8-1.) When a 50 ohm impedance antenna is used, the RF signal is delivered to the input amplifier of the RF plug-in unit through connector J3 and attenuator AT1. The attenuator is a variable T-pad with a range of approximately 0 to -60 db.

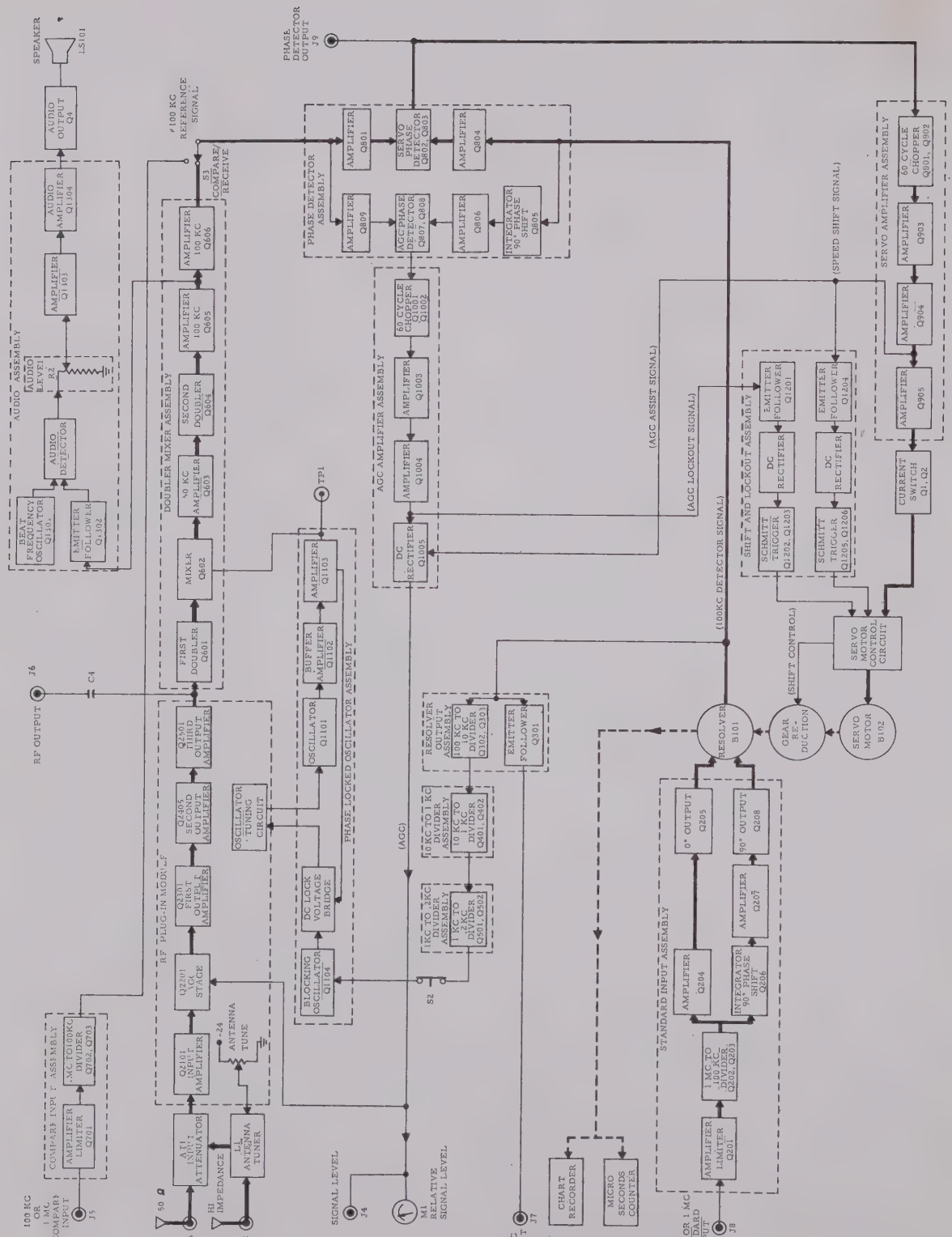


Figure 4-1. System Block Diagram

4-17. When a high impedance antenna is used, the RF signal is delivered to the input amplifier through connector J2, antenna tuner L1, and the attenuator. The tuner is a saturable reactor which is tuned by varying the amount of dc current through the control winding. Two variable resistors, in series with the 24 vdc supply for the control winding, vary the dc current. ANT TUNE resistor R4 functions as the fine control. The other variable resistor is mounted on the RF plug-in unit and functions as the coarse or pre-set control.

4-18. The remote antenna control consists of connector J1 and the R section of frequency selector switch S1. When the frequency selector switch is rotated, continuity is made between pin 1 of the connector and the pin corresponding to the selected plug-in unit. An additional section of the switch may be wired to connector J1 if another circuit is needed.

4-19. RF MODULE. (See figure 8-16.) The RF module provides an output signal of approximately 0.1 vrms to the doubler mixer assembly. Because of the AGC action, the actual gain through the five stages is a function of input signal level. The module also includes the antenna tuning resistor (R2001) and the tank circuit for the phase locked detector.

4-20. The input amplifier includes a single tuned input tank circuit and provides approximately 30 db gain. The output is directly coupled to the AGC stage which operates as an emitter follower.

4-21. The AGC voltage is applied to diode CR2202 and provides forward bias for the two diodes. The two diodes function as a variable attenuator to the signal. As the input signal increases, the AGC voltage from the AGC amplifier assembly goes negative. As the AGC voltage goes negative, the current flow through the diodes increases. The increased current flow effectively decreases the resistance to ground and thus increases attenuation of the signal.

4-22. The AGC circuit is RC coupled to the first of three output amplifier stages. The first two stages include a tuned collector tank circuit and are RC coupled to the next stage. The third stage includes a broad band collector circuit and is capacitively coupled to the next stage. Part of the emitter is un-bypassed to stabilize the stage gain. Each of the stages provides a gain of approximately 30 db.

4-23. DOUBLER MIXER ASSEMBLY. (See figure 8-7.) The doubler mixer assembly receives the 0.1 rms (approx) VLF signal from the RF module and delivers a 100 KC signal of approximately 1.5V peak-to-peak to the phase detector.

4-24. Transistor Q601 operates as an emitter-follower, with the doubler portion in the emitter circuitry. When the VLF signal is below 30 KC, the doubled output, from the junction of resistors R604 and R605 is coupled to the mixer stage Q602. When the VLF signal is above 30 KC, and undoubled output from transformer T601 is coupled to the mixer stage. Coupling is accomplished through the frequency selector switch S1 and straps on the RF module.

4-25. The output of transistor Q601 is injected into transformer T601 between one tap and the grounded center. The transformer operates as an autotransformer with a total signal across diodes CR601 and CR602 of four times the injected signal. Since the diodes conduct on alternate halves of the cycle, the voltage variation across resistors R604 and R605 is twice the input frequency. The output signal, from the other transformer tap, is equal in frequency to the incoming signal but opposite in phase.

4-26. The output of the first doubler is RC coupled to the base of mixer stage Q602 and a frequency from the local oscillator is applied across the primary of transformer T602. The two signals are mixed in the emitter circuit of transistor Q602 and RC coupled to amplifier Q603. When the incoming VLF signal is below 72 KC, the mixed signal to amplifier Q603 is 50 KC. When the incoming signal is above 75 KC, the output signal is 100 KC.

4-27. Diodes CR603 and CR604 are used as switches, operating at the frequency of the local oscillator. During one half of the cycle, the signal from transistor Q602 is switched through, with mixing action, to the amplifier. During the other half cycle, the signal is switched off. Additional frequencies are present in the signal to amplifier Q603 but the 50 KC or 100 KC signal is selected by the tank circuit in the collector of Q603.

4-28. For 50 KC operation, the collector tank circuit of amplifier Q603 is tuned by capacitor C605. For 100 KC operation, an additional capacitor which is located in the RF module is connected in series with capacitor C605 to tune the circuit. Resistor R611 in the emitter circuit is un-bypassed to stabilize stage gain. The amplifier provides approximately 30 db of gain and is capacitively coupled to the second doubler stage Q604.

4-29. The second doubler operates in the same manner as the first doubler. When the incoming VLF signal is below 75 KC, the doubled output is RC coupled to amplifier Q605. When the incoming signal is above 75 KC, the undoubled output is used. As in the first doubler, coupling is accomplished through the frequency selector switch S1 and straps on the RF module.

4-30. Amplifier Q605 provides approximately 12 db of gain and delivers a 100 KC signal to amplifier Q606 through the 10 cps bandwidth filter FL1. Stabilization and impedance matching is provided by the un-bypassed collector.

4-31. Amplifier Q606 provides 30 db of gain and delivers the 1.5V peak-to-peak signal to the phase detector.

4-32. STANDARD INPUT ASSEMBLY. (See figure 8-3.) The signal from the local standard is amplified and converted to two 100 KC signals (a 0° and a 90° out-of-phase signal) in the standard input assembly and delivered to the resolver. The circuits are designed to convert 1 MC or 100 KC sine wave or square waves in the 0.5 to 5 vrms range.

4-33. Amplifier-limiter Q201 converts the input signal to a semi-square wave of approximately 1 V peak-to-peak. Large input signals are limited and shaped by diodes CR201 and CR202 in the input circuit. Smaller input signals are amplified and then shaped and limited by diodes CR203 and CR204 in the output circuit.

4-34. The output of the amplifier-limiter triggers the divider Q202 and Q203. The divider is a multivibrator which is set to free-run at approximately 92 KC. The trigger pulses override the time constants of the circuit and provide a 100 KC output. When the input signal is 100 KC, the output of the divider is a symmetrical square wave, locked to the incoming signal. When the input signal is 1 MC, the output is a slightly asymmetrical square wave, locked to one-tenth of the incoming signal frequency. The output square wave is

shaped to a sine wave by indicator L201 and capacitor C209.

4-35. The time constants of the circuit are set by the emitter coupling circuit consisting of capacitor C207, resistors R210 and R216, and potentiometer R217. Potentiometer R217 therefore provides adjustment of the free running frequency. Potentiometer R212, in the base circuit of transistor Q203, is a trigger level adjustment. The divider receives both a positive and negative trigger pulse from the input signal, therefore both halves of the output signal are controlled. As shown in figure 4-2, a 100 KC input signal provides triggering pulses in a symmetrical pattern and therefore the output is a symmetrical square wave. However, a 1 MC input signal provides an opposing pulse at the midpoint of the wave and will not shift the multivibrator to the alternate flip-flop condition. The multivibrator will remain in its previous condition until the aiding pulse is received at the end of the next half cycle of the incoming pulse. With the unsymmetrical triggering, the divider output signal is an asymmetrical square wave. Proper adjustment of the trigger level potentiometer controls the degree of asymmetry and sets the divider function of the circuit.

4-36. The 100 KC sine wave is amplified by Q204 and applied to the resolver as the 0° input through transistor Q205. Amplifier C204 amplifies the incoming signal from approximately 1V peak-to-peak to approximately 9V peak-to-peak. Output stage Q205 operates as a low impedance driver with the 0° stator coil of the resolver in the emitter circuit.

4-37. The 100 KC sine wave is also applied to integrator Q206 which shifts the incoming signal by 90°. The 90° signal is amplified by Q207 and applied to the resolver through transistor Q209. The integrator circuit, as shown in simplified form in figure 4-3, has a relatively large open loop gain as compared to the unity closed loop gain. The output sine wave is therefore an accurate integral of the input sine wave, or the input sine wave shifted by 90°. The integrator receives a 1V peak-to-peak signal and delivers a 1V peak-to-peak quadrature signal to amplifier Q207. Potentiometer R227, in the emitter circuit, is the gain control and balances the amplitude of the two signals to the resolver. Amplifier Q207 and output stage Q208 operate in the same manner as amplifier Q204 and output stage Q205.

4-38. RESOLVER. (See figure 8-2.) The resolver receives two signals equal in amplitude but shifted in phase by 90° from the standard input assembly and delivers a single signal to the phase detector assembly. The two signals are applied to the rotor of the resolver and the phase of the output signal is determined by its position in relation to the output winding on the stator. The rotor is controlled, through a gear train, by the servo motor.

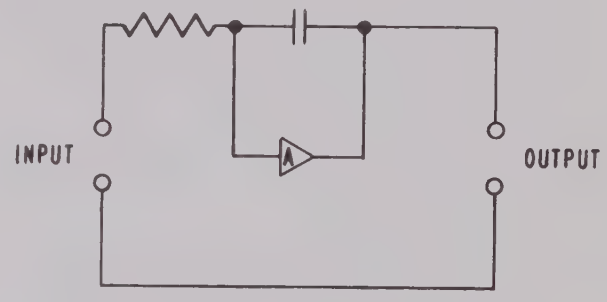


Figure 4-3. Integrator Circuit, Simplified Diagram

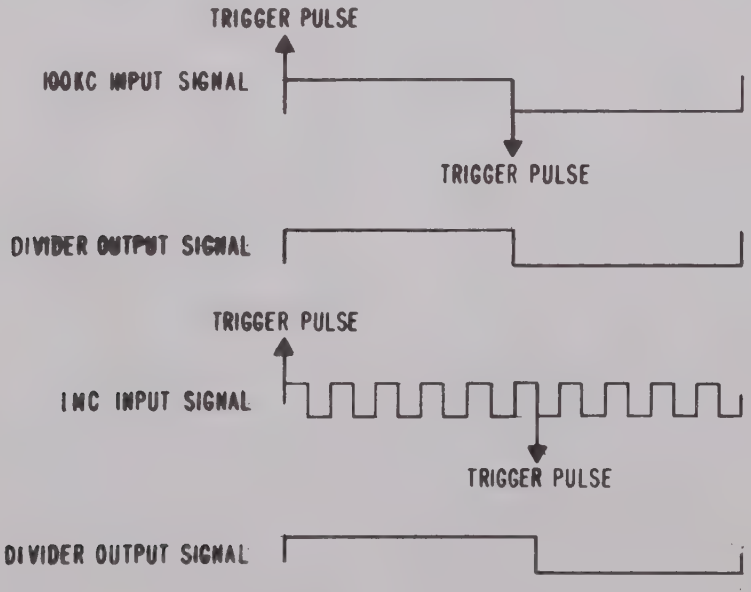


Figure 4-2. Divider Circuit, Input-to-Output Signals

4-39. PHASE DETECTOR ASSEMBLY. (See figure 8-9.) The 100 KC signal from the resolver is compared to a 100 KC reference signal from the doubler mixer assembly in the phase detector. One dc output from the phase detector assembly is applied to the servo amplifier assembly and to connector J18. The second dc output is applied to the AGC amplifier assembly.

4-40. The 100 KC signal from the resolver is applied through capacitor C805 and emitter follower Q804 to transformer T801. The secondary of transformer T801 and transistors Q802 and Q803 form a half wave switching circuit with the transistors inverted for better switching action. When the voltage applied to the base of the transistors is negative with respect to the collector voltage, the transistors conduct. On the alternate half cycle, the voltages to the transistors are reversed and the transistors are cut off.

4-41. The 100 KC reference signal from the doubler mixer assembly is applied through capacitor C801 and emitter follower Q801 to capacitor C802. When transistors Q802 and Q803 conduct, any signal appearing at C802 is short circuited to the common ground. When the transistors are cut off, any signal appearing at C802 is applied to the dc filter circuit composed resistors R804, R805, R808 and capacitor C803.

4-42. The polarity and amplitude of the dc output signal is determined by the phase relationship of the two incoming signals. When the two signals are exactly inphase, the output is a maximum positive voltage. At 90° out-of-phase, the output is zero and at 180° out-of-phase, the output is a maximum negative voltage. Figure 4-4 shows a family of waveforms existing in the phase detector. When the two voltages are inphase, the transistor shorts the negative half cycle of the 100 KC reference signal to common. The output at capacitor C802 therefore has an average plus value. At 90° out-of-phase, the average output is zero and at 180° out-of-phase the average output is negative.

4-43. As long as the phase relations of the two input signals remain constant, the output of the phase detector is a steady dc voltage. The phase relations remain constant only when the two signals have exactly the same frequency. When the two signals vary in frequency, the phase relations vary over the given length of time and the output is a slowly varying dc voltage. Figure 4-5 shows the phase detector waveforms and output for a difference in frequency. The frequency of the varying dc voltage is equal to the difference in frequency between the two input signals.

4-44. The filtering circuit, consisting of resistor R804 and capacitor C803 provides a long time constant to average out noise voltages and yet allow response to the slowly varying phase difference voltage. When the system is in the high speed mode, a shorter time constant is required to allow response to more rapid changes. To reduce the time constant and also maintain a constant output voltage, resistors R805 and R808 are connected to the filtering circuit as shown in figure 4-6.

4-45. The AGC phase detector circuit operates in the same manner as the servo phase detector except that a 90° phase shift is introduced by integrator Q805. The integrator is similar to integrator Q206 in the standard input assembly. As a result of the phase shift, the output of the AGC phase detector is a maximum negative voltage when the servo phase detector is at null. Since the amplitude of the 100 KC reference signal is directly related to incoming VLF signal strength, the amplitude of the phase detector output is also related to incoming VLF signal strength.

4-46. SERVO AMPLIFIER ASSEMBLY. (See figure 8-10.) The servo amplifier receives a dc signal from the phase detector assembly and a 60 cps reference voltage from the power input line. The dc signal is converted to a 60 cps output to the servo motor. The phase of the output signal with respect to the 60 cps reference voltage determines the direction of rotation of the servo motor.

4-47. The dc signal is applied across the chopper Q901 and Q902 to the base of amplifier Q903. The 60 cps reference voltage is applied to the primary of transformer T901. The secondary of T901 and transistors Q901 and Q902 operate as a 60 cps switching circuit similar to the phase detector switching circuits. When the voltage applied to the base of the transistors is negative with respect to the collector, the transistors conduct and short the dc signal to ground. During the alternate half cycle, the transistors are cut off and any positive or negative dc voltage is applied to the base of transistor Q903.

4-48. When the system is at null, the output dc voltage from the servo phase detector is at ground potential. The switching circuit will not affect the dc voltage since the switch is from ground to ground. However, if the system is off null, the output of the phase detector is either a positive or negative dc voltage. When the dc voltage is positive, the output signal from the chopper is a 60 cps square wave, inphase with the 60 cps reference signal. When the dc voltage is negative, the square wave output is 180° out-of-phase with the 60 cps reference signal. (See figure 4-8.)

4-49. The output from the chopper is amplified by transistor Q903 and Q904. The amplifiers also function as shaper circuits and, through feedback, carefully preserve the input to output phase relations.

4-50. The square wave output of Q904 is applied through the capacitor C908 to the shift and lockout assembly and to the AGC amplifier assembly. The output to the shift and lockout assembly shifts the system into the high speed mode during periods of rapid change when the servo switch S4 is in the auto position. The output to the AGC amplifier assembly is used to maintain a constant AGC voltage during periods of off-null operation.

4-51. The output of Q904 is also amplified by Q905 and applied through capacitor C909 to the servo motor circuit (see figure 4-7). Diodes CR901 through CR904 form a full wave bridge rectifier for the 60 cps with a normal pulsating dc output to the shading coils of the servo motor. However, when transistors Q1 and Q2 are cut off, the circuit is broken and the rectifier does not have an output. The transistors are cut off when the system is at null and during the positive half cycle of the square wave input signal. During the negative half cycle of the input signal, the base of the transistors are negative and the transistors conduct. While the transistors conduct, the coils of the motor receive a positive pulse of current. (See figure 4-8.) The positive pulse is followed by a half cycle of non-current flow. Effectively, the shaded coils receive an ac signal which is either inphase or 180° out-of-phase with the field coil voltage. The phase relation determines whether the motor turns clockwise or counterclockwise.

4-52. AGC AMPLIFIER ASSEMBLY. (See figure 8-11.) The AGC amplifier assembly receives a dc signal from the AGC phase detector and an ac signal from the servo amplifier assembly. The two signals are combined and supply a dc voltage to the AGC stage of the RF plug-in module, level meter M1, and signal jack J4.

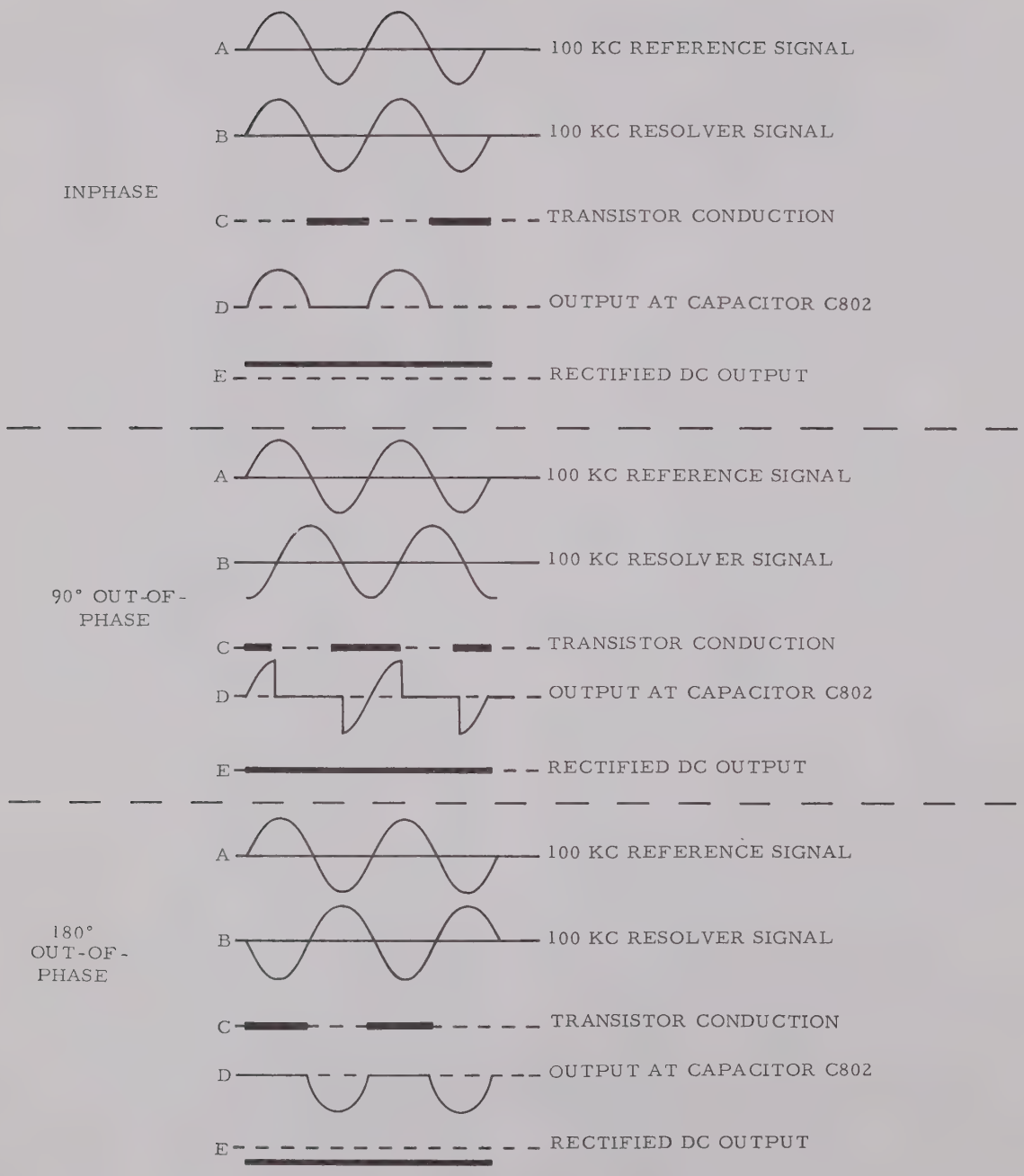


Figure 4-4. Phase Detector Waveforms

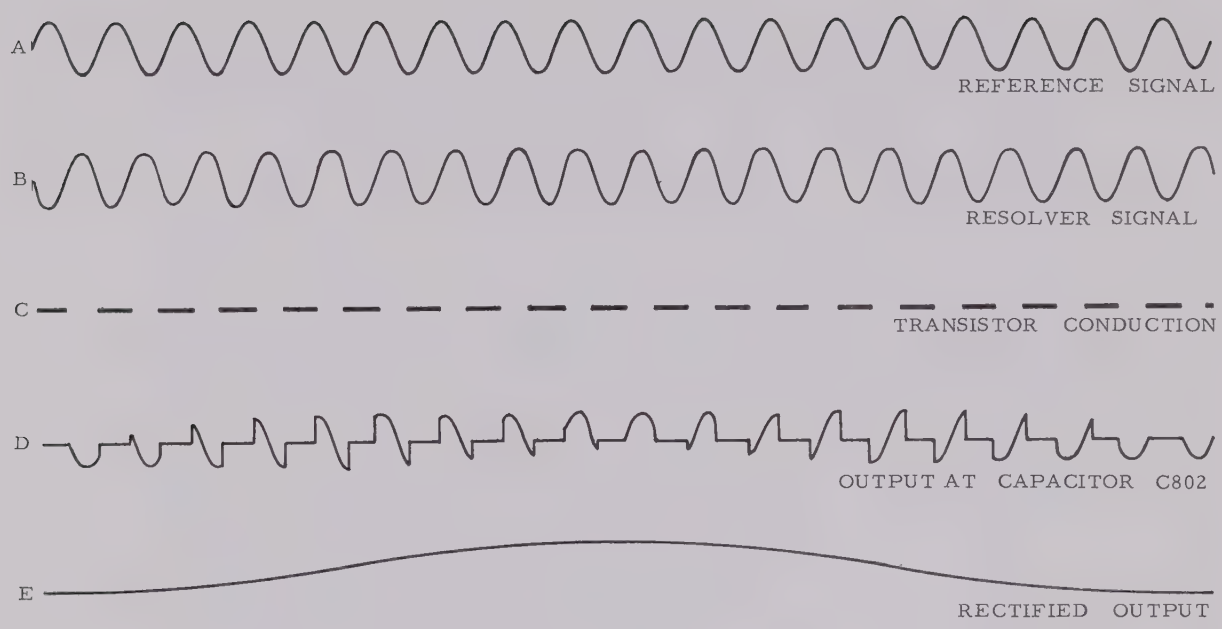


Figure 4-5. Phase Detector Operation for Difference in Frequency

4-53. The dc input from the phase detector is converted to a 60 cycle square wave in chopper Q1001 and Q1002. The chopper operates in the same manner as the servo amplifier assembly chopper. The square wave output of the chopper is shaped and amplified in amplifiers Q1003 and Q1004. Potentiometer R1013 provides adjustment of the AGC level by controlling the gain of the stage.

4-54. The square wave output from amplifier Q1004 is applied to the shift and lockout assembly. This signal stops the chart drive when the input VLF signal drops below the level required to maintain the phase locked condition (with lockout switch S5 in the auto position).

4-55. The square wave output is also applied through capacitor C1006 to the dc rectifier circuit in the input of transistor Q1005. A second square wave signal, from amplifier Q904 of the servo amplifier assembly, is applied to the rectifier circuit through capacitor C1007, potentiometer R1015, and capacitor C1008. The two input signals are mixed to form the AGC voltage which is applied to the outputs through emitter follower Q1005. Potentiometer R1015 provides the means for controlling the sensitivity to the signal from the servo amplifier assembly.

4-56. At null, the output from the AGC phase detector is maximum and the output from the servo phase detector is minimum. Therefore at null, the full AGC voltage is supplied by the AGC phase detector since no input is received from the servo amplifier. Off null, the output from the AGC phase detector is reduced regardless of input VLF signal level. At the same time, an input will be received from the servo amplifier assembly. The two inputs provide a relatively steady AGC voltage under all phase conditions.

4-57. Potentiometer R1021, in the output stage, sets the dc level to one side of meter M1 and determines the relative level which the meter will indicate.

4-58. SHIFT AND LOCKOUT ASSEMBLY. (See figure 8-13.) The shift and lockout assembly receives one square wave input signal from the servo amplifier which is converted to a dc current. This dc current output releases the high speed relay when the error voltage in the servo amplifier is excessive. A second square wave input from the AGC amplifier is also converted to dc current and controls the lockout relay of the servo motor control circuit.

4-59. The signal from the AGC amplifier is applied through capacitor C1201 to the base of emitter-follower Q1201. The output of the emitter follower is rectified in the input circuit of amplifier Q1202. The amplified dc output of Q1201 is applied to the base of Schmitt Trigger Q1203 and operates as the trigger control voltage.

4-60. With no signal input, Q1203 conducts. As the input signal increases, the base of Q1202 goes negative and therefore the base of Q1203 goes positive. When the positive voltage overcomes the negative bias, the transistor is cut off and cuts off current to the relay coil. Potentiometer R1203, in the emitter circuit of Q1201, adjusts the threshold level of the circuit.

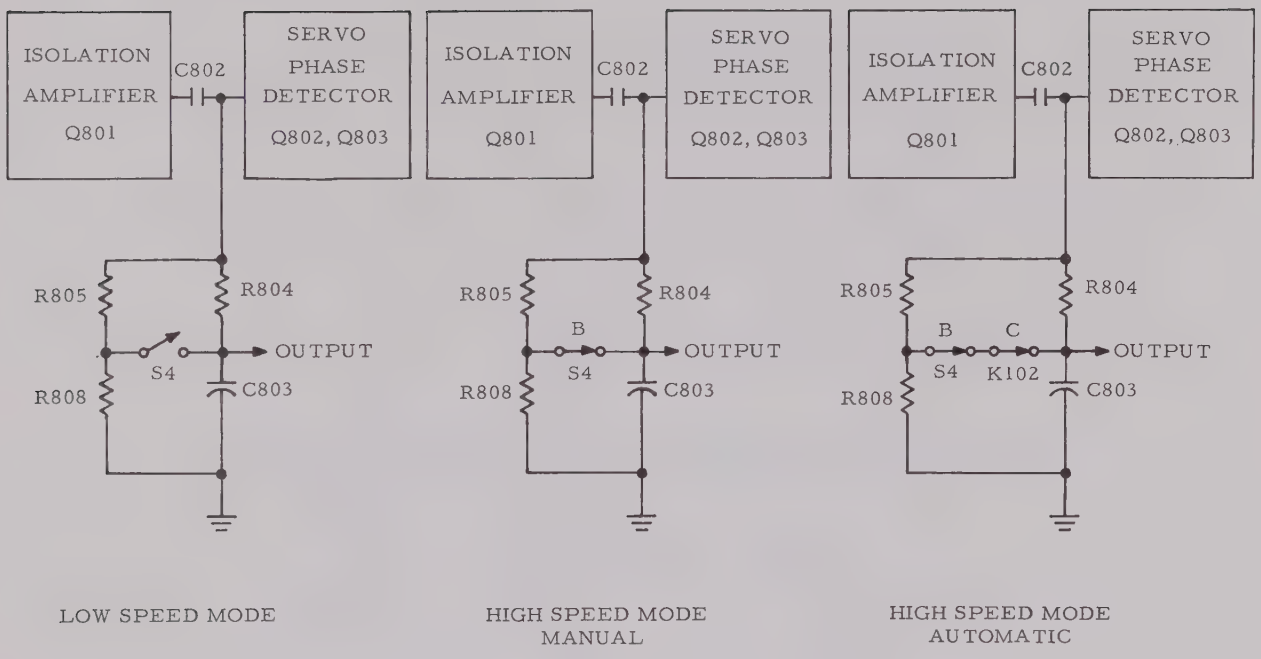


Figure 4-6. Phase Detector Filtering Circuit

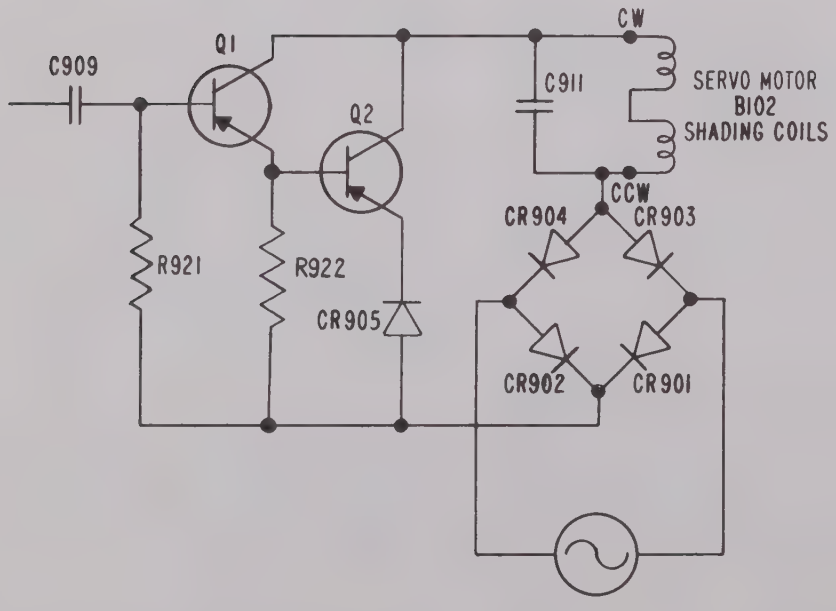


Figure 4-7. Servo Motor Current Circuit

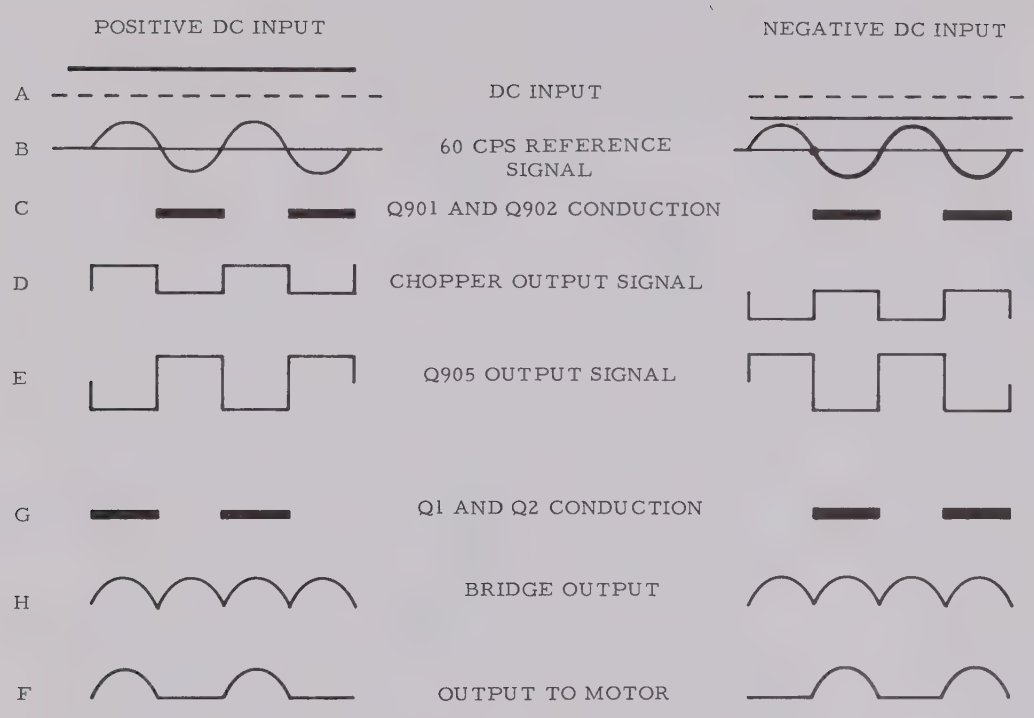


Figure 4-8. Servo Amplifier Waveforms

4-61. With an input VLF signal level of 0.1 microvolts or more, the AGC amplifier will produce sufficient output to release the relay. When the VLF signal level drops below 0.1 microvolts, transistor Q1203 conducts and operates the relay.

4-62. The circuit for servo amplifier assembly operates in the same manner. In normal operation, the relay operates when the phase error in the system is approximately 0.5 microseconds.

4-63. RESOLVER OUTPUT ASSEMBLY. (See figure 8-4.) The resolver output assembly receives a 100 KC phase locked signal from the resolver and delivers a 100 KC output signal to the 100 KC output jack J7 and a 10 KC square wave output to the 10 KC to 1 KC divider assembly.

4-64. The 100 KC signal is applied to emitter follower Q301 through capacitor C302. The emitter follower is primarily an impedance matching device and provides a 1 vrms, 100 KC signal for external use or monitoring.

4-65. The 100 KC signal is also applied through capacitor C303 to the 10 to 1 divider circuit. The divider operates in the same manner as the 1 MC to 100 KC divider circuit in the standard input assembly.

4-66. 10 KC TO 1 KC DIVIDER ASSEMBLY. (See figure 8-5.) The 10 KC to 1 KC divider assembly receives a 10 KC square wave input from the resolver output assembly and delivers a 1 KC square wave output to the 1 KC to .2 KC divider assembly. The divider operates in the same manner as the 1 MC to 100 KC divider. Since the divider receives a square wave of fixed amplitude, the shaping and limiting diodes are not required.

4-67. 1 KC TO .2 KC DIVIDER ASSEMBLY. (See figure 8-6.) The 1 KC to .2 KC divider assembly receives a 1 KC square wave input and delivers a .2 KC square wave to the phase locked oscillator assembly. The divider operates in the same manner as the 1 MC to 100 KC divider circuit in the standard input assembly. Again, the shaping and limiting diodes are not required. In dividing by five, the divider receives triggering pulses in an approximately symmetrical pattern and therefore the output square wave is approximately symmetrical.

4-68. PHASE LOCKED OSCILLATOR ASSEMBLY. (See figure 8-12.) The phase locked oscillator assembly produces a 0.5 peak-to-peak signal of the frequency required to obtain a 100 KC reference signal from the doubler-mixer assembly. The oscillator tuning circuit is located on the RF plug-in module and is preset at the factory. Variations in the output frequency, and thus in the 100 KC reference signal, are eliminated through a phase lock circuit. The 100 KC signal from the resolver, through a series of frequency dividers, provides the locking signal.

4-69. The local oscillator uses a highly stabilized, Hartley type oscillator circuit. The amplitude of oscillation is limited by diode CR2601 and resistor R2602 in parallel with the tank circuit. A reverse-biased silicon diode CR2602 is used as the locking element and acts as a capacitor controlled by the dc voltage from the diode bridge.

4-70. The output of the local oscillator is applied to the mixer Q602 through buffer amplifier Q1102 and the emitter follower portion of amplifier Q1103, the output is also supplied to TP1 through terminal H for servicing or monitoring purposes. The small unbypassed resistor R1112 in the emitter of Q1103 produces a signal of approximately 0.5 volts, peak-to-peak.

4-71. An 8 volt peak-to-peak signal from the collector circuit of Q1103 functions as the source for the phase lock signal. This signal is referenced to -15 vdc through the voltage divider network consisting of resistors R1117, R1118, and R1120 and zener diode CR1105. The signal is applied to the diode bridge CR1101, CR1102, CR1103, and CR1104 which operate as a gate circuit. When no signal is received from blocking oscillator Q1104, the diode bridge operates as a full wave rectifier and -15 vdc is applied to the silicon diode in the oscillator tank circuit.

4-72. The blocking oscillator Q1104 receives a triggering pulse from the divider circuits every 200 cps and produces a 20V, 6 microsecond, gate pulse which is applied to the diode bridge. When the pulse is applied, all four diodes conduct and apply a portion of the signal from transistor Q1103 to the silicon diode in oscillator tank circuit. The signal portion is filtered by resistors R1115 and R1117 and capacitor C1109 and is applied to the diode as an average dc voltage.

4-73. As shown in figure 4-9, the dc voltage level is determined by the phase (thus frequency) relationships between the signal from Q1103 and the triggering pulse from the divider circuits. If the local oscillator drifts, the phase relations change producing a change in the dc output. The change in dc output changes the effective capacitance of the silicon diode and automatically corrects the frequency drift.

4-74. COMPARE INPUT ASSEMBLY. (See figure 8-8.) When MODE switch S2 is turned to the COMPARE position, the signal from COMPARE INPUT connector J5 is converted to a 100 KC square wave in the compare input assembly and delivered to the phase detector assembly. The circuit is designed to accept 100 KC or 1 MC sine wave or square wave inputs in the 0.5 to 5 vrms range. The circuits are similar in operation to the first two stages (Q201, Q202 and Q203) of the standard input assembly.

4-75. AUDIO ASSEMBLY. (See figure 8-14.) The audio assembly receives a 100 KC signal from the doubler mixer assembly which is mixed with the output of a beat frequency oscillator to produce a 1 KC audio signal. The audio signal is amplified and delivered to the speaker LS101 through the audio output stage Q4.

4-76. The 100 KC signal is applied to the base of emitter follower Q1302 through capacitor C1304. The emitter follower operates as an impedance matching device. The signal is applied to the center-tapped secondary of transformer T1301.

4-77. Beat frequency oscillator Q1301 is a Hartley oscillator which produces a 99 KC signal across the secondary of transformer T1301. Diodes CR1301 and CR1302 conduct during half the cycle and apply the 100 KC signal to resistor R1307. During the alternate half cycle, the diodes are cut off and the 100 KC signal is isolated. As with the phase detector (see figure 4-5), the average rectified output of this circuit is the difference frequency between the two signals.

4-78. The rectified output of the detector is amplified by transistors Q1303 and Q1304 and applied to current

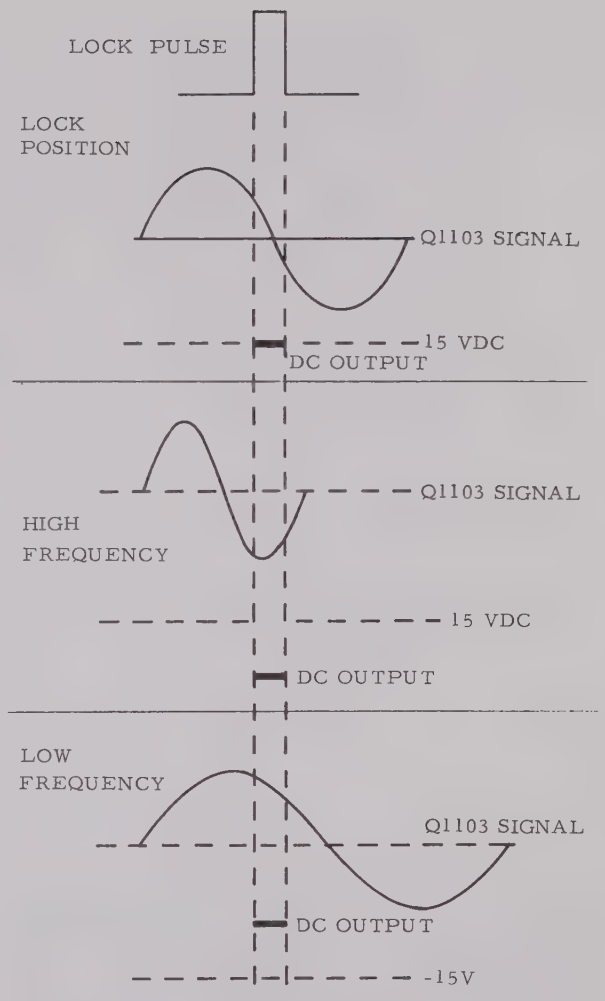


Figure 4-9. Locking Bridge Waveforms

amplifier Q4. The speaker coil is in the emitter circuit of Q4.

4-79. RECORDER-SERVO ASSEMBLY. (See figure 8-2.) The servo motor B102 drives the resolver, the pin of the chart recorder, and the microseconds counter through a series of gears. The direction of rotation is determined by the phase of the voltage applied to the shaded coil windings of the servo motor.

4-80. The field coil of the servo motor is supplied with 115 vac power as shown in figure 4-10. With SERVO LOCKOUT switch S5 in the AUTO position and SERVO switch S4 in any position but OFF, the power circuit is completed by contacts of relay K101 or K102. With the SERVO LOCKOUT switch S5 in the OFF position, the control relays are by-passed.

4-81. Relay K102 is controlled by the speed shift signal from the shift and lockout assembly. When the phase error exceeds the tracking ability of the servo system, Schmitt trigger Q1206 in the shift and lockout assembly is cut off and relay K102 is released. With the relay released and SERVO switch S4 in the AUTO

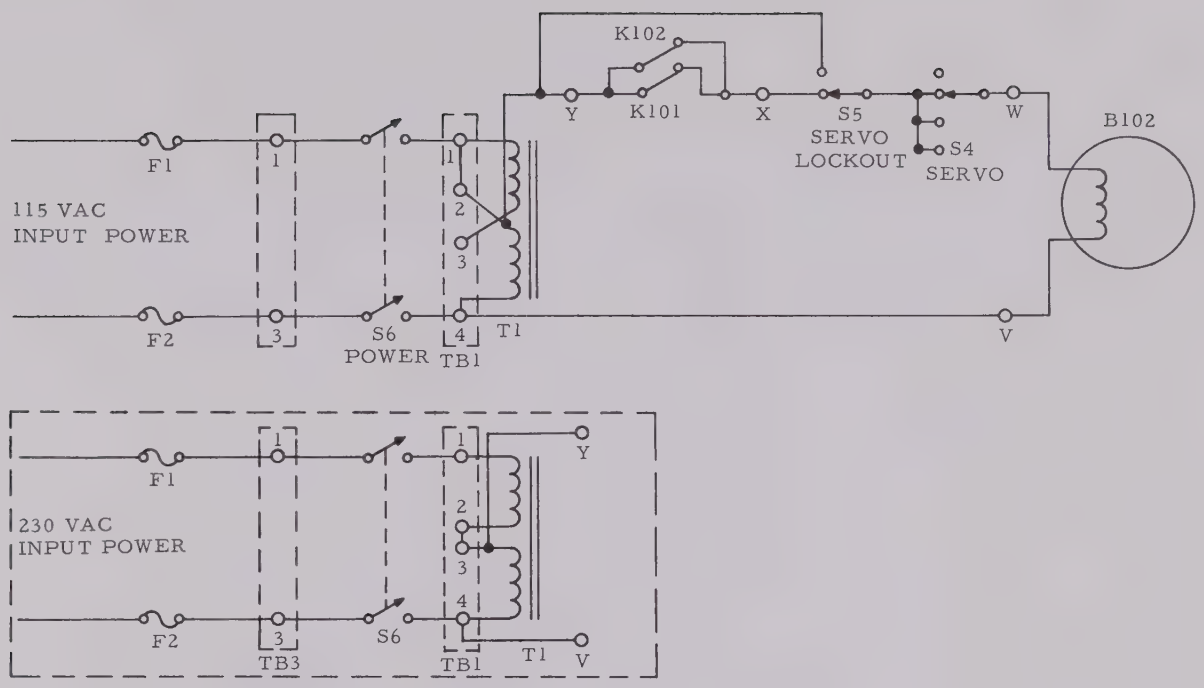


Figure 4-10. Servo Motor Field Coil Circuit

position, solenoids L101 and L102 are energized. Solenoid L101 controls the speed shift mechanism and solenoid L102 controls the high speed marker of the chart recorder. When SERVO switch S4 is turned to the FAST position, relay K102 is bypassed and solenoids L101 and L102 are energized through contacts of switch S4.

4-82. The speed shift mechanism consists of a planetary gear assembly and the arm of solenoid L101. When solenoid L101 is de-energized, the solenoid arm engages with the ring gear of the planetary gear assembly and holds the ring gear stationary. With the ring gear held stationary, the internal gears rotate and apply a 100:1 reduction through the gear assembly. When the solenoid is energized, the arm is disengaged and the ring gear is free to rotate. With the ring gear free to rotate, the input to output gear reduction is by-passed.

4-83. Relay K101 is controlled by the AGC level signal from the shift and lockout assembly. When the output of the AGC phase detector is below a predetermined level, Schmitt trigger Q1203 in the shift and lockout assembly conducts and relay K101 is energized. If relay K101 is energized while relay K102 is de-energized, the servo system is not affected. If relay K102 is energized, relay K101 completes the circuit to solenoid L103 and the AGC dropout marker appears. If the SERVO LOCKOUT switch is in the AUTO position and both relays are energized, the field coil circuit for servo motor B102 is broken.

4-84. POWER SUPPLY. (See figures 8-1 and 8-15.) The power supply converts 115 vac or 230 vac input power to -18 vdc and -24 vdc regulated power and to a 6 vac servo reference voltage.

4-85. The input power is fused and applied to power transformer T1 through terminal board TB1. The unit is converted to 115 vac or 230 vac by placement of links on terminal board TB1. When 115 vac power is used, the dual primaries of T1 are placed in parallel. For 230 vac power, the primaries are placed in series.

4-86. The 26 vac output of transformer T1 is converted to vdc by full wave rectifier bridge CR1401, CR1402, CR1403, and CR1404, a capacitor input filter circuit and the regulator circuit. The -18 vdc output is regulated by zener diode CR1.

4-87. The 24 volt supply is regulated by transistor Q3 operating as an emitter follower. Transistor Q1402 is referenced to -18 vdc by zener diode CR1 and senses the output voltage developed across resistors R1403, R1404 and R1405. Variable resistor R1404 sets the output voltage level. Variations in output level are amplified by transistor Q1402 and used to control the conduction of transistor Q3 through transistor Q1401.

SECTION V

MAINTENANCE

5-1. SCHEDULED MAINTENANCE.

5-2. Once every year, the unit should be checked for mechanical defects such as damaged components or insulation, loose hardware, etc., and should be cleaned using a vacuum cleaner. Under normal operating conditions, check, align and adjust the receiver once a year as outlined in Section VI.

5-3. SERVICING.

5-4. Most problems with the receiver will be apparent from the chart recording and can be isolated to an assembly or a specific circuit from the front panel. Refer to Section IX for examples of normal and abnormal chart recordings. To check individual assemblies, refer to the schematics included in Section VIII and to Table 4 for normal signal levels in an operating equipment.

TABLE 4. NORMAL SIGNAL LEVELS

CONDITION	MEASURE POINT	SIGNAL		NOTES
		FREQUENCY	VOLTAGE LEVEL	
A. Standard Input Board Assembly A2				
1 vrms at 1 mc into STANDARD INPUT connector J8	Base of Q202	1 mc	0.5 V peak-to-peak	Rounded square wave
	Junction R214 and R215	100 KC	1.5 V peak-to-peak	Distorted square wave
	Base of Q204	100 KC	1.3 V peak-to-peak	Sine wave
	Base of Q205	100 KC	12 V peak-to-peak	Sine wave
	Collector of Q206	100 KC	1.3 V peak-to-peak	Sine wave
	Base of Q208	100 KC	12 V peak-to-peak	Sine wave
	Terminal B	100 KC	12 V peak-to-peak	Sine wave
	Terminal D	100 KC	12 V peak-to-peak	Sine wave
Disconnect 1 mc input signal	Junction R214 and R215	84 KC (approx)	1.5 V peak-to-peak	Distorted square wave
B. Resolver Output Board Assembly A3				
1 vrms at 1 mc into STANDARD INPUT connector J8	Terminal A	100 KC	9 V peak-to-peak	Sine wave
	Terminal D	100 KC	5 V peak-to-peak	Sine wave
	Base of Q302	100 KC	4.5 V peak-to-peak	Distorted square wave
	Terminal C	10 KC	1.2 V peak-to-peak	Square wave
Ground terminal A	Terminal C	8.3 KC (approx)	1.2 V peak-to-peak	Square wave
C. 10 KC to 1 KC Divider Board Assembly A4				
1 vrms at 1 mc into STANDARD INPUT connector J8	Base of Q401	10 KC	.35 V peak-to-peak	Square wave
	Terminal B	1 KC	1.4 V peak-to-peak	Square wave
Ground junction of R313, R314 and C307 (A3)	Terminal B	800 cps	1.4 V peak-to-peak	Square wave
D. 1 to 0.2 KC Divider Board Assembly A5				
1 vrms at 1 mc into STANDARD INPUT connector J8	Base of Q501	1 KC	.4 V peak-to-peak	Square wave
	Terminal B	200 cps	1.7 V peak-to-peak	Square wave
Ground terminal A (A5)	Terminal B	160 cps (approx)	1.7 V peak-to-peak	Square wave

TABLE 4. NORMAL SIGNAL LEVELS (Continued)

CONDITIONS	MEASURE POINT	SIGNAL		NOTES
		FREQUENCY	VOLTAGE LEVEL	
E. Compare Input Board Assembly A7				
1 vrms at 1 mc into COMPARE INPUT connector J5, MODE switch S3 to COMPARE	Base of Q702	1 mc	.5 V peak-to-peak	Rounded square wave
	Terminal B	100 KC	.6 V peak-to-peak	Square wave
Disconnect 1 mc signal	Terminal B	86 KC (approx)	.6 V peak-to-peak	Square wave
F. Locked Oscillator Board Assembly A11				
1 vrms at 1 mc into STANDARD INPUT connector J8, MODE switch S3 to RECEIVE	Terminal A	200 cps	1.6 V peak-to-peak	Square wave
	Collector of Q1104	200 pulses per second	18 V peak-to-peak	8 us pulse
	Base of Q1102	Locked oscillator frequency for selected channel	40 millivolt, peak-to-peak	Sine wave
	Terminal H	Locked oscillator frequency	.5 V peak-to-peak	Sine wave
	Collector of Q1103	Locked oscillator frequency	4 V peak-to-peak	Sine wave
	Across R1117	DC	3 vdc	
G. RF Module				
RF ATTEN control set to MIN, 1 uv at channel frequency applied to 50 Ω ANT connector, -1 vdc applied to SIGNAL LEVEL jack	RF OUTPUT connector J6	Channel frequency	.5 to 1.0 V peak-to-peak	Sine wave
H. Doubler-Mixer Board Assembly A6				
RF ATTEN control set to MIN, 1 uv at channel frequency applied to 50 Ω ANT connector, -1 vdc applied to SIGNAL LEVEL jack	Terminal A	Channel frequency	.5 to 1.0 V peak-to-peak	Sine wave
1. Channel frequency below 30 KC	Base of Q602	2 times channel frequency	70 millivolt, peak-to-peak	Full wave rectified sine wave
2. Channel frequency above 30 KC	Base of Q602	Channel frequency	200 millivolt, peak-to-peak	Sine wave

TABLE 4. NORMAL SIGNAL LEVELS (Continued)

CONDITIONS	MEASURE POINT	SIGNAL		NOTES
		FREQUENCY	VOLTAGE LEVEL	
H. Doubler-Mixer Board Assembly A6 (Continued)				
	Terminal E	Locked oscillator frequency	.25 V peak-to-peak	Sine wave
	Base of Q604	50 KC	.1 V peak-to-peak	Sine wave
	Terminal L	100 KC	.3 V peak-to-peak	Sine wave
	Terminal N	100 KC	.05 V peak-to-peak	Sine wave
	Terminal P	100 KC	1 V peak-to-peak	Sine wave
I. Phase Detector Board Assembly A8				
MODE switch S3 to COMPARE, SERVO switch to FAST	PHASE DETECTOR OUTPUT connector	dc	< .02 vdc	
1 vrms at 1 mc (or 100 KC) to STANDARD and COMPARE INPUT connectors	Terminal F	dc	-.2 vdc (approx)	
J. Servo Amplifier Board Assembly A9				
Apply -1 vdc to PHASE DETECTOR OUTPUT connector	Terminal L	60 cps	5 V peak-to-peak	Sloped square wave
Apply short to PHASE DETECTOR OUTPUT connector	Terminal M	60 cps	8 V peak-to-peak	Full wave rectified sine wave
K. AGC Amplifier Board Assembly A10				
Apply -.2 vdc to terminal A (A10)	Collector of Q1003	60 cps	1 V peak-to-peak	Square wave
	Terminal B	60 cps	2 V peak-to-peak (depends on setting of R1013)	Square wave
	Base of Q1005	DC	-.12 vdc	
	Terminal C	DC	+1.0 vdc	
	Terminal E	DC	+1.0 vdc	
Apply ground to terminal A (A10)	Base of Q1005	DC	.6 vdc	
Apply .1 vdc to PHASE DETECTOR OUTPUT connector				

TABLE 4. NORMAL SIGNAL LEVELS (Continued)

CONDITIONS	MEASURE POINT	SIGNAL		NOTES
		FREQUENCY	VOLTAGE LEVEL	
L. Shift and Lockout Board Assembly A12				
Apply 30 millivolt dc to PHASE DETECTOR OUTPUT connector	Base of Q1205	DC	-1 vdc	
	Collector of Q1205	DC	-22 vdc	
	Emitter of Q1205	DC	-1.5 vdc	
	Emitter of Q1206	DC	-1.5 vdc	
	Base of Q1206	DC	-1.8 vdc	
	Collector of Q1206	DC	-1.8 vdc	
Apply 70 millivolt dc to PHASE DETECTOR OUTPUT connector	Base of Q1205	DC	-1.7 vdc	
	Collector of Q1205	DC	-1.7 vdc	
	Emitter of Q1205	DC	-1.5 vdc	
	Emitter of Q1206	DC	-.25 vdc	
	Base of Q1206	DC	-.25 vdc	
	Collector of Q1206	DC	-24 vdc	
Apply -.1 vdc to terminal A of AGC amplifier board assembly	Emitter of Q1202	DC	-.8 vdc	
	Base of Q1202	DC	-.5 vdc	
	Collector of Q1202	DC	-18 vdc	
	Emitter of Q1203	DC	-.8 vdc	
	Base of Q1203	DC	-1.0 vdc	
	Collector of Q2103	DC	-.9 vdc	
Apply -.2 vdc to terminal A of AGC amplifier board assembly	Emitter of Q1202	DC	-.4 vdc	
	Base of Q1202	DC	-.6 vdc	
	Collector of Q1202	DC	-.4 vdc	
	Emitter of Q1203	DC	-.1 vdc	
	Base of Q1203	DC	-.2 vdc	
	Collector of Q1203	DC	-24 vdc	

TABLE 4. NORMAL SIGNAL LEVELS (Continued)

CONDITIONS	MEASURE POINT	SIGNAL		NOTES
		FREQUENCY	VOLTAGE LEVEL	
M. Audio Board Assembly A13				
Turn AUDIO GAIN control full clockwise	Collector of Q1301	100 KC ±1 KC (approx)	40 V peak-to-peak	
	Emitter of Q1302	100 KC	.3 V peak-to-peak	Modulated approximately 30% by audio beat note
Apply .3 V peak-to-peak at 100 KC to terminal A (A13)	Collector of Q1303	1 KC (approx)	.5 V peak-to-peak	Audio beat
	Terminal B	1 KC (approx)	24 V peak-to-peak	Reduces to zero when AUDIO GAIN control is turned CCW
N. Power Supply Board Assembly A14				
	Terminal V and W	60 cps	26.5 vrms	
	Terminal C and ground	DC	30 vdc	
		120 cps ripple	4 V peak-to-peak (approx)	
	Terminal B	DC	24.3 vdc	
	Terminal E	DC	24.0	
		120 cps ripple	Less than 50 mv peak-to-peak	
	Terminal Z	DC	18 vdc (approx)	
	Base of Q1402	DC	18 vdc (approx)	

SECTION VI

ALIGNMENT AND ADJUSTMENT

6-1. GENERAL.

6-2. This section includes a checkout procedure for the Model PCR in addition to the alignment and adjustment procedures. To locate the various components identified in the procedures, refer to the parts list section.

6-3. TEST EQUIPMENT.

6-4. To checkout, align, and adjust the unit, the following equipment (or equivalent) is required:

a. Vacuum tube voltmeter, Hewlett Packard Model 400D.

b. Frequency counter, Hewlett Packard Model 523D.

c. Signal generator, Hewlett Packard Model 200 CD.

d. Oscilloscope

e. Variable dc voltage supply, 0 to 1 vdc range (continuously variable from 10 to 100 mv).

f. Attenuator, Hewlett Packard Model 355B.

6-5. POWER SUPPLY CHECK.

6-6. To checkout the power supply, proceed as follows:

a. Turn FREQUENCY switch to any operating channel.

b. Turn MODE switch to RECEIVE position.

c. Turn AUDIO GAIN control clockwise from OFF position.

d. Turn POWER switch on.

e. Check that POWER indicator lights.

f. Measure dc voltage across Zener diode CR1. The voltage shall be between 16.2 and 19.8 vdc.

g. Measure dc voltage of terminal E of power supply board assembly A14. (The terminal board is identified with Part No. OM1097.)

h. Check that the voltage is between 23.5 and 24.5 vdc. Adjust potentiometer R1404, if required, to set voltage within limits.

i. Turn AUDIO GAIN control to off position and then clockwise from the off position. The voltage at terminal E (OM1097) shall vary no more than 0.1 vdc.

6-7. DIVIDER ADJUSTMENTS.

6-8. To adjust the divider circuit of standard input board assembly A2 (the terminal board is identified with Part No. OM1067), proceed as follows:

a. Connect oscilloscope and frequency counter to the junction of resistors R212, R214, and coil L201.

b. Connect signal generator to the STANDARD INPUT connector and set output amplitude to zero.

c. Make certain that the MODE switch is in the RECEIVE position.

d. Adjust potentiometers R212 and R217 as required to obtain a free-running frequency of approximately 83 KC as shown on the counter and a symmetrical square wave (see figure 4-2) as shown on the oscilloscope. Although there is considerable interaction between the two potentiometers, potentiometer R217 primarily affects free-running frequency and potentiometer R212 primarily affects wave shape.

e. Check that the output voltage, measured with the oscilloscope, is approximately 1.5 volts peak-to-peak.

f. Adjust the signal generator to deliver 1 mc at 1 vrms.

g. The divider output frequency as measured by the frequency counter, shall be exactly one-tenth the signal generator frequency (100 KC).

h. Vary output frequency of the signal generator from 950 to 1050 KC.

i. The divider circuit shall remain locked (output frequency one-tenth the input frequency) throughout the range. Readjust potentiometers R212 and R217, if required, to center the lock range of the divider circuit to 1 mc.

j. Reset the signal generator to 1 mc and decrease output amplitude until the output waveform of the divider indicates loss of lock (the waveform jitters).

k. The divider circuit shall remain locked to 0.3 vrms or less.

l. Increase amplitude of signal generator from 0.3 to 5.5 vrms.

m. The divider circuit shall remain locked throughout the 0.3 to 5.5 vrms range.

6-9. To adjust the divider circuit of resolver output board assembly A3 (the terminal board is identified with Part No. OM1068), proceed as follows:

a. Connect oscilloscope and frequency counter to the junction of resistors R313, R314 and capacitor C307.

b. Ground terminal A of the resolver output assembly.

c. Adjust potentiometers R311 and R316 as required to obtain a free-running frequency of approximately 8.3 KC as shown on the counter and a symmetrical square wave (see figure 4-2) as shown on the oscilloscope. Potentiometer R316 primarily affects frequency and potentiometer R311 primarily affects wave shape.

d. The output level shall be approximately 1 volt peak-to-peak, as measured with the oscilloscope.

e. Remove ground from terminal A of the resolver output board assembly and set signal generator to 1 mc at 1 vrms.

f. The divider output frequency shall be exactly 1/100 the signal generator frequency (or 10 KC).

g. Vary output frequency of the signal generator from 750 to 1050 KC.

h. The divider circuit shall remain locked (output frequency 1/100 the input frequency) throughout the range. Readjust potentiometers R311 and R316 as required to center the lock range of the divider.

6-10. To adjust the divider circuit of 10 to 1 KC divider board assembly A4 (the terminal board is identified with Part No. OM1069), proceed as follows:

a. Connect oscilloscope and frequency counter to terminal B of the 10 to 1 KC divider board assembly.

b. Ground terminal A of the 10 to 1 KC divider board assembly.

c. Adjust potentiometers R407 and R412 as required to obtain a free-running frequency of approximately 700 cps as shown on the counter and a symmetrical square wave (see figure 4-2) as shown on the oscilloscope. Potentiometer R412 primarily affects frequency and potentiometer R407 primarily affects wave shape.

d. The output level shall be approximately 1 volt peak-to-peak, as measured with the oscilloscope.

e. Remove ground from terminal A of the 10 to 1 KC divider board assembly and set signal generator to 1 mc at 1 vrms.

f. The divider output frequency shall be exactly 1/1000 the signal generator frequency (1 KC).

g. Vary output frequency of the signal generator from 950 to 1050 KC.

h. The divider circuit shall remain locked (output frequency 1/1000 the input frequency) throughout the range. Readjust potentiometers R407 and R412 as required to center the lock range of the divider.

6-11. To adjust the divider circuit of 1 to .2 KC divider board assembly A5 (the terminal board is identified with Part No. OM1070), proceed as follows:

a. Connect oscilloscope and frequency counter to terminal B of the 1 to .2 KC divider board assembly.

b. Ground terminal A of the 1 to .2 KC divider board assembly.

c. Adjust potentiometers R507 and R512 as required to obtain a free-running frequency of approximately 160 cps as shown on the counter and a symmetrical square wave (see figure 4-2) as shown on the oscilloscope. Potentiometer R512 primarily affects frequency and potentiometer R507 primarily affects wave shape.

d. The output level shall be approximately 1 volt peak-to-peak, as measured with the oscilloscope.

e. Remove ground from terminal A of the 1 to .2 KC divider board assembly and set signal generator to 1 mc at 1 vrms.

f. The divider output frequency shall be exactly 1/5000 the signal generator frequency (200 cps).

g. Vary output frequency of the signal generator from 950 to 1050 KC.

h. The divider circuit shall remain locked (output frequency 1/5000 the input frequency) throughout the range. Readjust potentiometers R507 and R512 as required to center the lock range of the divider.

6-12. To adjust the divider circuit of compare input board assembly A7 (the terminal board is identified with Part No. OM1072), proceed as follows:

a. Connect oscilloscope and frequency counter to terminal B of the compare input board assembly.

b. Connect signal generator to the COMPARE INPUT connector and set output amplitude to zero.

c. Turn the MODE switch to the COMPARE position.

d. Adjust potentiometers R712 and R717 as required to obtain a free-running frequency of approximately 83 KC as shown on the counter and a symmetrical square wave (see figure 4-2) as shown on the oscilloscope. Potentiometer R717 primarily affects free-running frequency and potentiometer R712 primarily affects wave shape.

e. The output level shall be approximately 1 volt peak-to-peak, as measured with the oscilloscope.

f. Adjust the signal generator to deliver 1 mc at 1 vrms.

g. The divider output frequency, as measured by the counter, shall be exactly one-tenth the signal generator frequency (100 KC).

h. Vary output frequency of the signal generator from 950 to 1050 KC.

i. The divider circuit shall remain locked (output frequency one-tenth the input frequency) throughout the range. Readjust potentiometers R712 and R717, if required, to center the lock range of the divider circuit to 1 mc.

j. Reset the signal generator to 1 mc and decrease output amplitude until the output waveform of the divider indicates loss of lock (the waveform jitters).

k. The divider shall remain locked to 0.3 vrms or less.

l. Increase amplitude of signal generator from 0.3 to 5.5 vrms.

m. The divider circuit shall remain locked throughout the 0.3 to 5.5 vrms range.

6-13. RESOLVER INPUT ADJUSTMENT.

6-14. To adjust and test the signal input to the resolver, proceed as follows:

a. Connect oscilloscope to terminal B of standard input board assembly A2.

b. Connect signal generator to the STANDARD INPUT connector and set signal generator to 1 mc at 1 vrms.

c. Measure 0° input voltage to the resolver with the oscilloscope. The voltage shall be 12 ±1 volts peak-to-peak. Note the voltage.

d. Connect oscilloscope to terminal D of standard input board assembly A2.

e. Measure 90° input voltage to the resolver with the oscilloscope. Adjust potentiometer R227 as required

to set amplitude of 90° input equal to the 0° input noted in step c.

f. Connect vertical input of oscilloscope to terminal D and horizontal input to terminal B of standard input board assembly A2. Adjust oscilloscope to measure phase shift.

g. The Lissajous pattern shall indicate a 90° phase shift between the 0° and 90° resolver inputs.

6-15. RF ALIGNMENT.

6-16. To align the rf stages of the plug in module, proceed as follows:

a. Connect a -1 vdc source to the SIGNAL LEVEL connector.

b. Connect signal generator to the 50 OHM ANTENNA connector.

c. Connect oscilloscope to the RF OUTPUT connector.

d. Turn MODE switch to the RECEIVE position.

e. Set RF ATTEN (DB) control to the MIN position.

f. Turn FREQUENCY switch to the first operating channel and set signal generator to within ±2 cps of the channel frequency at 1 microvolt rms.

g. Adjust tuning transformers of the module for maximum rf output as indicated by the oscilloscope. The tuning slugs of the transformers are available from the top of the module and are identified as CHAN FREQ controls. The order of tuning is not critical.

h. The rf output shall be between 0.3 to 0.5 volt peak-to-peak, as measured by the oscilloscope.

i. Increase output of signal generator to 1 millivolt.

j. Vary RF ATTEN (DB) control over its full range. Check that the same rf output as noted in step h may be obtained through use of the RF ATTEN (DB) control.

k. Return RF ATTEN (DB) control to the MIN position and the output of the signal generator to 1 millivolt.

l. Repeat steps f through h for remaining channels.

6-17. To test and adjust the local oscillator, proceed as follows:

a. Connect a 1 mc standard to the STANDARD INPUT connector.

b. Connect oscilloscope and frequency counter to test point TP1.

c. Turn FREQUENCY switch to the first operating channel.

d. Determine local oscillator frequency from the OSC FREQ button on top of the applicable plug in module.

e. Press oscillator test switch S8 and check that free-running frequency of oscillator is within ±5 cps of the indicated frequency. Adjust the OSC FREQ tuning slug of the plug in module as required to set the free-running frequency.

f. Release test switch S8.

g. The locked frequency of the oscillator shall be within ±1 cps of the indicated frequency.

h. Turn FREQUENCY switch to another channel and then return. The local oscillator frequency shall return to within ±1 cps of the indicated frequency.

i. The output voltage at TP1 shall be 0.4 to 0.6 volt peak-to-peak, as measured by the oscilloscope.

j. Repeat test procedure for remaining channels.

6-18. To tune the doubler-mixer board assembly A6 (the terminal board is identified as Part No. OM1071), proceed as follows:

a. Connect oscilloscope and frequency counter to terminal P of doubler-mixer board assembly A6.

b. Turn FREQUENCY switch to any operating channel and set the signal generator to within ±2 cps of the applicable channel frequency at 1 microvolt rms.

c. Tune transformer T603 (Part No. TA335) as required to obtain maximum 100 KC output.

d. Tune transformer T605 (Part No. TA336) as required to obtain maximum 100 KC output.

e. Adjust the -1 vdc supply to the SIGNAL LEVEL connector as required until the level of the 100 KC output signal is 1 volt peak-to-peak.

f. Disconnect oscilloscope from terminal P, connect to the RF OUTPUT connector, and measure input level to the doubler-mixer.

g. The input level shall be between 0.3 and 0.5 volt peak-to-peak.

6-19. AUDIO CIRCUIT CHECKOUT.

6-20. To checkout the audio circuits, proceed as follows:

a. Connect oscilloscope to terminal A of audio board assembly A13 (the terminal board is identified as Part No. OM1096).

b. Adjust the -1 vdc supply to the SIGNAL LEVEL connector until the level of the 100 KC signal measured at terminal A is 1 volt peak-to-peak.

c. Connect oscilloscope to the emitter of Q4.

d. Turn AUDIO GAIN control clockwise to the maximum gain position.

e. Tune transformer T1301 (Part No. TA341) to obtain the best audio tone at or near 1000 cps.

f. Check that the audio output waveform is relatively undistorted and that the amplitude is 5 volts peak-to-peak or more.

6-21. SERVO SYSTEM ADJUSTMENT AND CHECK-OUT.

6-22. To balance the servo motor, proceed as follows:

a. Disconnect the 1 mc standard from the STANDARD INPUT connector.

b. Connect the variable dc voltage supply to the PHASE DETECTOR OUTPUT connector.

c. Remove chart magazine from unit (so that the servo motor shaft may be observed directly).

d. Turn SERVO switch to the FAST position.

e. Turn SERVO LOCKOUT switch to the OFF position.

f. Starting from zero, increase voltage output of dc supply until the servo motor shaft starts to rotate. Note voltage at which shaft starts to rotate.

g. Reverse polarity of dc supply voltage and repeat step f.

h. Adjust potentiometer R903 as required until the voltages required to start the servo motor in either direction are equal.

6-23. To test threshold voltage, proceed as follows:

a. Starting from zero, increase voltage output of dc supply until the servo motor shaft starts to rotate.

b. The servo motor shall start to rotate at 10 mv or less.

c. Reverse polarity of dc supply and repeat steps a and b.

d. Turn SERVO switch to the SLOW position.

e. Starting from zero, increase voltage output of dc supply until the servo motor shaft starts to rotate.

f. The servo motor shall start to rotate at 20 mv or less.

g. Reverse polarity of dc supply and repeat steps a and b.

6-24. To test motor speed, proceed as follows:

a. Turn SERVO switch to the FAST position.

b. Set voltage output of dc supply to zero and note position of servo motor shaft.

c. Set output of dc supply to 100 mv and check time required for shaft of servo motor to complete one revolution.

d. The servo motor shall complete one revolution in ten seconds or less.

e. Reverse polarity of supply and repeat test.

f. Replace chart magazine.

6-25. To test speed shift adjustment, proceed as follows:

a. Turn SERVO switch to the AUTO position.

b. Set voltage output of dc supply to zero.

c. Check that high speed marker does not appear on the right hand margin of the chart.

d. Increase output of voltage supply until the high speed marker appears and the unit operates in the high speed mode.

e. The marker shall appear when the output of the voltage supply is between 50 and 70 mv. If marker does not appear within limits, adjust potentiometer R1212 as required.

f. Slowly reduce voltage until the high speed marker disappears.

g. The marker shall disappear when the voltage is between 50 and 70 mv.

6-26. AGC ADJUSTMENT AND CHECKOUT.

NOTE

The AGC circuit is adjusted at the factory using phase-locked input signals. The following procedure may be used as a checkout and a rough field adjustment of the AGC circuit. To reset the AGC circuit to exact specifications, the unit should be returned to the factory.

6-27. To adjust the AGC level, proceed as follows:

a. Disconnect all test equipment.

b. Connect 1 mc standard to the STANDARD INPUT connector.

c. Connect signal generator, through an rf attenuator, to the 50 OHM ANTENNA connector.

d. Connect a -0.2 vdc voltage source to terminal F of phase detector board assembly A8.

e. Connect a ground to terminal B of phase detector board assembly A8.

f. Connect oscilloscope to terminal P of doubler-mixer board assembly A6.

g. Turn FREQUENCY switch to any operating channel and set the signal generator to within ±2 cps of the applicable channel frequency.

h. Set signal generator output level to 1 millivolt, set external rf attenuator to -60 db (1 microvolt into receiver), and set RF ATTEN (DB) control to the MIN position.

i. Turn MODE switch to the RECEIVE position.

j. Adjust the voltage source as required to maintain a -.2 vdc level at terminal F of the phase detector board assembly A8.

k. Carefully adjust the signal generator and the 1 mc standard to obtain maximum 100 KC output at terminal P of the doubler-mixer board assembly A6.

l. Adjust potentiometer R1013 as required to obtain a 0.7 volt peak-to-peak output at terminal P of the doubler-mixer.

m. Adjust potentiometer R1021 as required to obtain a 0 db indication on the SIGNAL LEVEL meter.

6-28. To adjust the level of the AGC assist voltage, proceed as follows:

a. Remove -0.2 vdc voltage source from terminal F of phase detector board assembly A8 and connect ground to terminal.

b. Remove ground from terminal B and connect -0.2 vdc voltage source to terminal.

c. Allow time for system stabilization and adjust the voltage source as required to maintain a -.2 vdc level at terminal B.

d. Adjust potentiometer R1015 as required to obtain a 0.7 volt peak-to-peak output at terminal P of the doubler-mixer.

6-29. To adjust the lockout level of the AGC system, proceed as follows:

a. Turn CHART DRIVE switch ON.

b. With -.2 vdc applied to terminal B of phase detector board assembly A8, check that the lockout marker is not present on the left margin of the chart paper.

c. Decrease voltage applied to terminal B until the lockout marker appears on the left margin of the chart paper and then increase voltage until the marker disappears.

d. The marker shall disappear at -.1 vdc. If required, readjust potentiometer R1203.

6-30. FINAL CHECKOUT.

6-31. To check compare mode operation, proceed as follows:

a. Connect 1 mc standard to both the STANDARD and COMPARE INPUT connectors.

b. Turn MODE switch to the COMPARE position.

c. Turn SERVO switch to the FAST position.

d. Turn SERVO LOCKOUT switch to the AUTO position.

e. Turn CHART DRIVE switch on.

f. Set chart speed to four inches per hour.

g. Allow at least one minute for unit stabilization.

h. Note MICROSECONDS COUNTER indication.

i. Allow unit to operate for five minutes.

j. The chart recording shall indicate no error over the five minute period. The maximum deviation from a straight vertical line recording shall not exceed 0.5 microsecond.

k. The signal failure marker shall not be present on the left margin of the chart.

l. The fast speed marker shall be present on the right margin of the chart.

6-32. To check receiver mode operation, proceed as follows:

a. Operate equipment as outlined in paragraph 3-4 with a chart speed of four inches per hour.

b. Check operation on each channel for a period of 15 minutes or more. If possible, perform checks during maximum reception periods and during periods when diurnal shift will not affect the error indication.

c. Check that the error indication is consistent for all channels.

SECTION VII

PARTS LIST

OVERALL UNIT

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
A1	Recorder Assembly (See figure 7-5)	Gertsch	AA962
A2	Standard Input Board Assembly (See figure 7-7)	Gertsch	AA966
A3	Resolver Output Board Assembly (See figure 7-8)	Gertsch	AA967
A4	10 KC to 1 KC Divider Board Assembly (See figure 7-9)	Gertsch	AA968
A5	1 to 0.2 KC Divider Board Assembly (See figure 7-10)	Gertsch	AA969
A6	Doubler Mixer Board Assembly (See figure 7-11)	Gertsch	AA970
A7	Compare Input Board Assembly (See figure 7-12)	Gertsch	AA971
A8	Phase Detector Board Assembly (See figure 7-13)	Gertsch	AA972
A9	Servo Amplifier Board Assembly (See figure 7-14)	Gertsch	AA973
A10	AGC Amplifier Board Assembly (See figure 7-15)	Gertsch	AA974
A11	Locked Oscillator Board Assembly (See figure 7-16)	Gertsch	AA975
A12	Shift and Lockout Board Assembly (See figure 7-17)	Gertsch	AA984
A13	Audio Board Assembly (See figure 7-18)	Gertsch	AA985
A14	Power Supply Board Assembly (See figure 7-19)	Gertsch	AA986
A15	RF Module, Channel 1	Gertsch	RFM-1 (Freq)
A16	RF Module, Channel 2	Gertsch	RFM-1 (Freq)
A17	RF Module, Channel 3	Gertsch	RFM-1 (Freq)
A18	RF Module, Channel 4	Gertsch	RFM-1 (Freq)
AT1	Attenuator, T pad, 50 ohms	Clarostat	CIT43-50
C1	Capacitor, electrolytic, 1000 uf, 50 vdcw	Sprague	TVL1338
C2	Capacitor, electrolytic, 1000 uf, 50 vdcw	Sprague	TVL1338
C3	Capacitor, electrolytic, 1000 uf, 50 vdcw	Sprague	TVL1338
C4	Capacitor, metallized paper, 0.1 uf, 200 vdcw	Aerovox	P8292ZN10
CR1	Diode, Zener	Hoffman	1N1819R
DS1	Lamp, Incandescent, 6V	General Electric	330
F1	Fuse, 1 AMP, Slo-Blo (115V OPR)	Bussmann	MDL 1
F1	Fuse, .5 AMP, Slo-Blo (230V OPR)	Bussmann	MDL 1-2
FL1	Filter, 100 KC	Raytheon	EM3000A
J1	Connector, receptacle		MS3102A18-1P
J2	Connector, BNC		UG-604/U
J3	Connector, BNC		UG-604/U
J4	Connector, BNC		UG-657U
J5	Connector, BNC		UG-604/U
J6	Connector, BNC		UG-657U
J7	Connector, BNC		UG-604/U

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
J8	Connector, BNC		UG-604/U
J9	Connector, BNC		UG-604/U
J10	Connector	Winchester	MRE21SJ
J11	Connector	Winchester	MRE9SG
J12	Connector	Winchester	MRE18SG
J13	Connector	Winchester	MRE9SG
J14	Connector	Winchester	MRE18SG
J15	Connector	Winchester	MRE9SG
J16	Connector	Winchester	MRE18SG
J17	Connector	Winchester	MRE9SG
J18	Connector	Winchester	MRE21SJ
L1	Inductor Assembly	Gertsch	TA376
M1	Meter	Gertsch	MA12
P1	P/O Power Cord	Belden	17406S
Q1	Transistor	Motorola	2N1360
Q2	Transistor	Motorola	2N1360
Q3	Transistor	Motorola	2N1360
Q4	Transistor	Motorola	2N1360
R1	Resistor, wirewound, 20 ohms, 5W	Dalohm	RH5
R2	Resistor, variable, 10K	Gertsch	RV57
R3	Resistor, composition, 1K ±10%, 1W		
R4	Resistor, variable, 1K	Gertsch	RV58
R5	Resistor, composition, 560 ohms ±10%, 1W		
R6	Resistor, composition, 100K ±10%, 2W		
R7	Resistor, composition, 100K ±10%, 2W		
R8	Resistor, composition, 100K ±10%, 2W		
R9	Resistor, composition, 100K ±10%, 2W		
S1	Switch, rotary	Gertsch	SW190
S2	Switch, push	Grayhill	30-2NC
S3	Switch	Gertsch	SW192
S4	Switch, rotary	Gertsch	SW189
S5	Switch	Gertsch	SW192
S6	Switch, SPST	Carling	110-B-73
S7	Switch, audio level		P/O R2
T1	Transformer, power	Triad	69227
TB1	Terminal Board	Cinch	1774-5101P24
TP1	Test Point	Ucinite	118930B
XDS1	Lampholder	Dialco	162-8430-931
XF1	Fuseholder	Littelfuse	342004
XQ1 thru XQ4	Socket, transistor	Motorola	MK20
M2	Counter	Bowmar	LC-1904-1
	Knob, bar (1 required)	Gertsch	AC91
	Knob, bar (2 required)	Gertsch	AC95
	Knob, red (1 required)	Gertsch	AC92-1
	Knob, black (1 required)	Gertsch	AC92-2

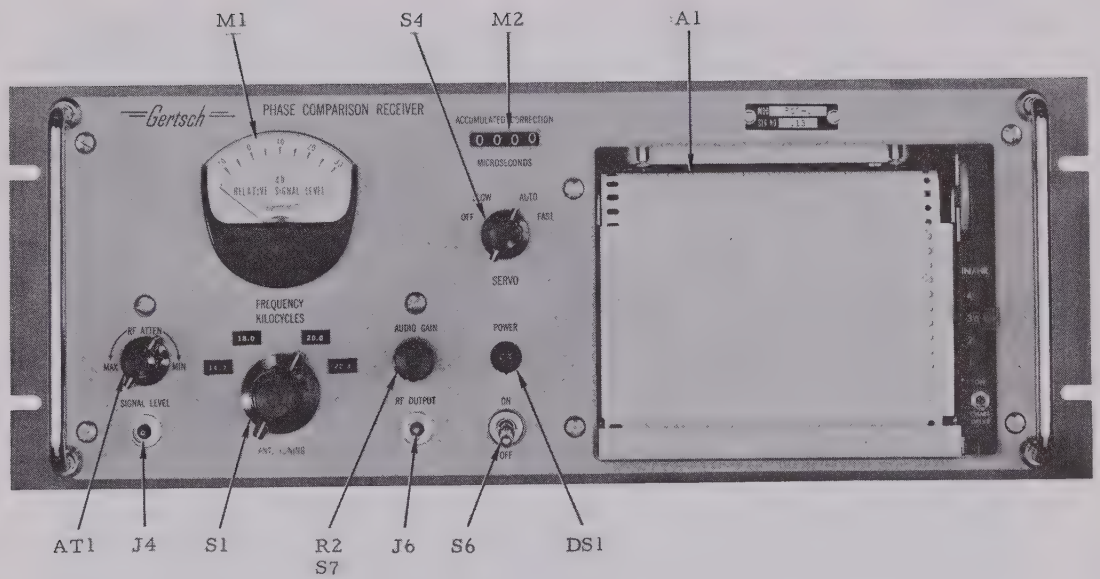


Figure 7-1. Front Panel

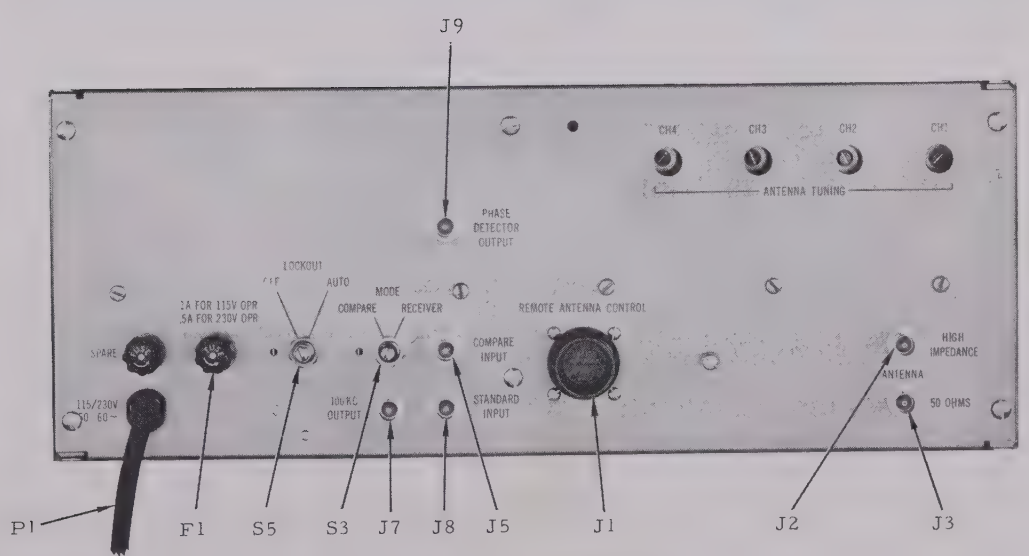


Figure 7-2. Rear Panel

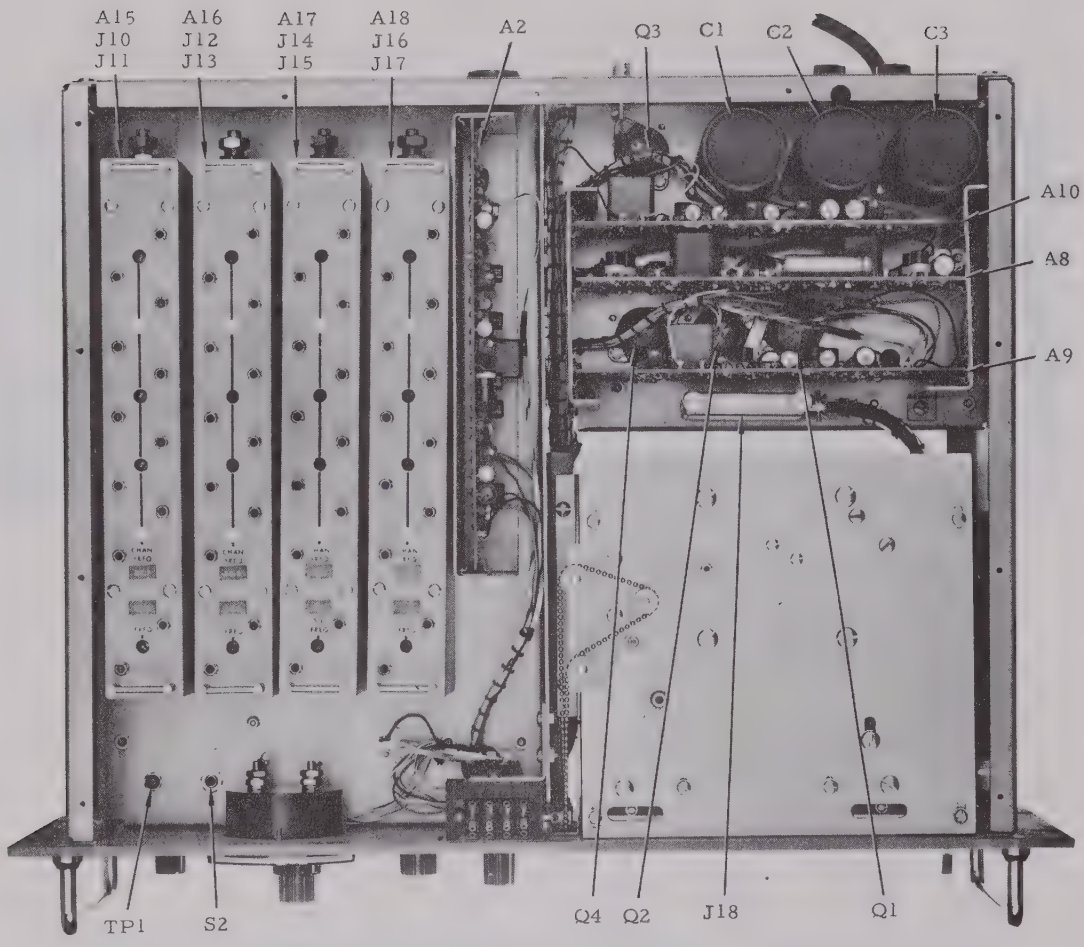


Figure 7-3. Component Location, Chassis Top

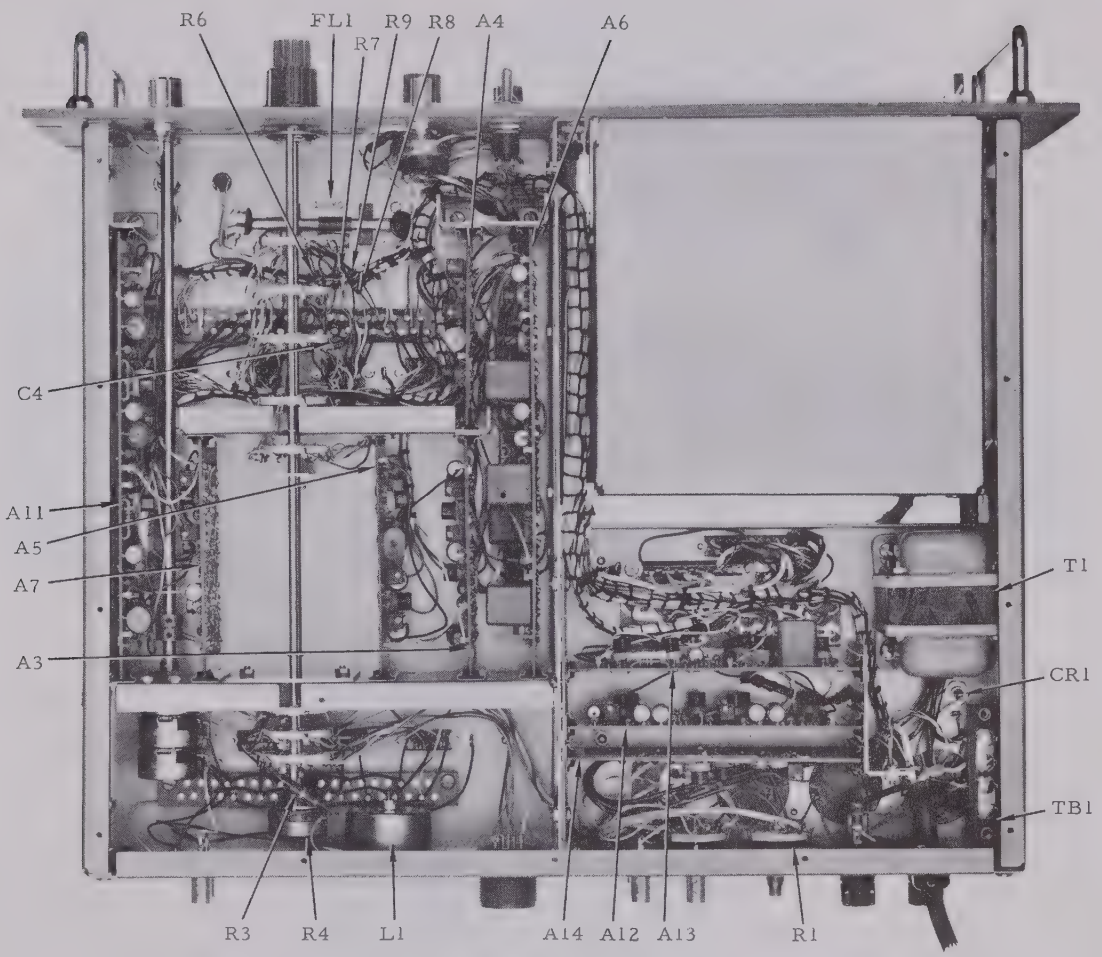


Figure 7-4. Component Location, Chassis Bottom

RECORDER ASSEMBLY
(See figure 7-5)

INDEX NO.	SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
-1		Chart	Gertsch	SC284
-2		Magazine, chart	F. L. Moseley	A-10064
-3	S101	Switch, toggle	Alco	MST-215N
-4	S102	Switch, sensitive	Microswitch	1SM1
-5		Enclosure Assembly	Gertsch	AA965
-6		Clock Drive Assembly	Gertsch	AA963
-7	B103	Motor, chart drive, 1/15 rpm, ccw	Gertsch	SC315
-8		Servo Assembly (See figure 7-6)		

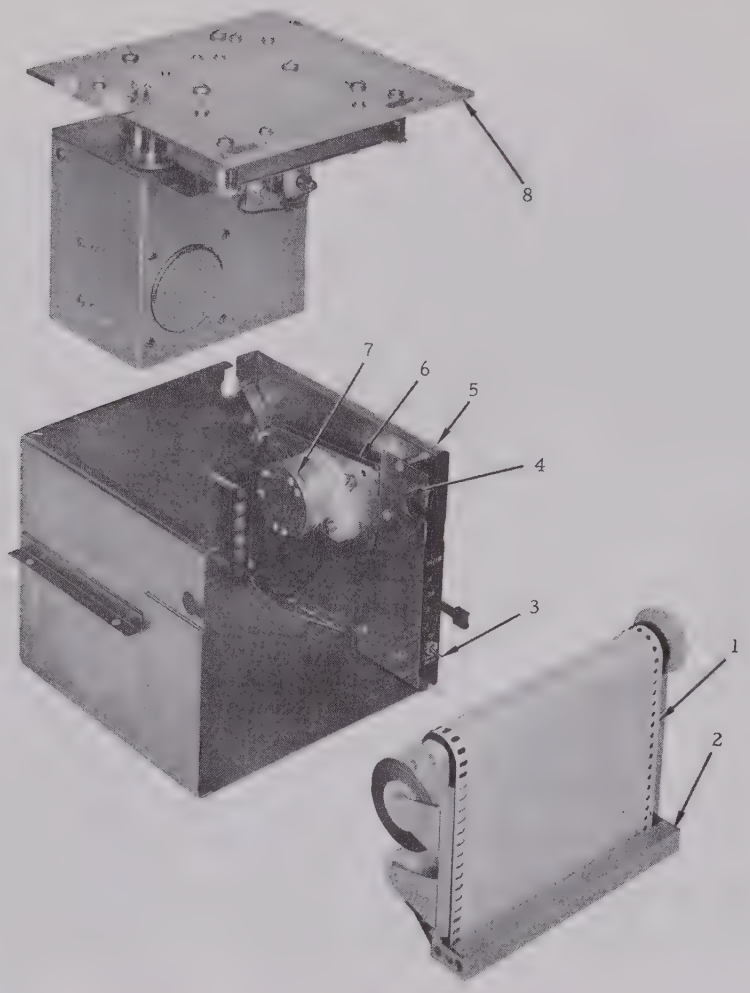


Figure 7-5. Recorder Assembly

SERVO ASSEMBLY
(See figure 7-6)

INDEX NO.	SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
-1	J101	Connector, plug	Winchester	MRE21P-JTCH1
-2		Stylus	Gertsch	SK872
-3		Tape Assembly	Gertsch	SK874
-4		Marker	Gertsch	OM1160
-5		Marker	Gertsch	OM1163
-6	L102	Solenoid, 115 vdc, No. 22 contact	Guardian	22DC-3300-C-115
-7	L103	Solenoid, 115 vdc, No. 22 contact	Guardian	22DC-3300-C-115
-8	CR109	Diode	Semtech	SC-2
-9	CR103	Diode	Semtech	SC-2
-10	CR104	Diode	Semtech	SC-2
-11	CR108	Diode	Semtech	SC-2
-12	CR107	Diode	Semtech	SC-2
-13	CR105	Diode	Semtech	SC-2

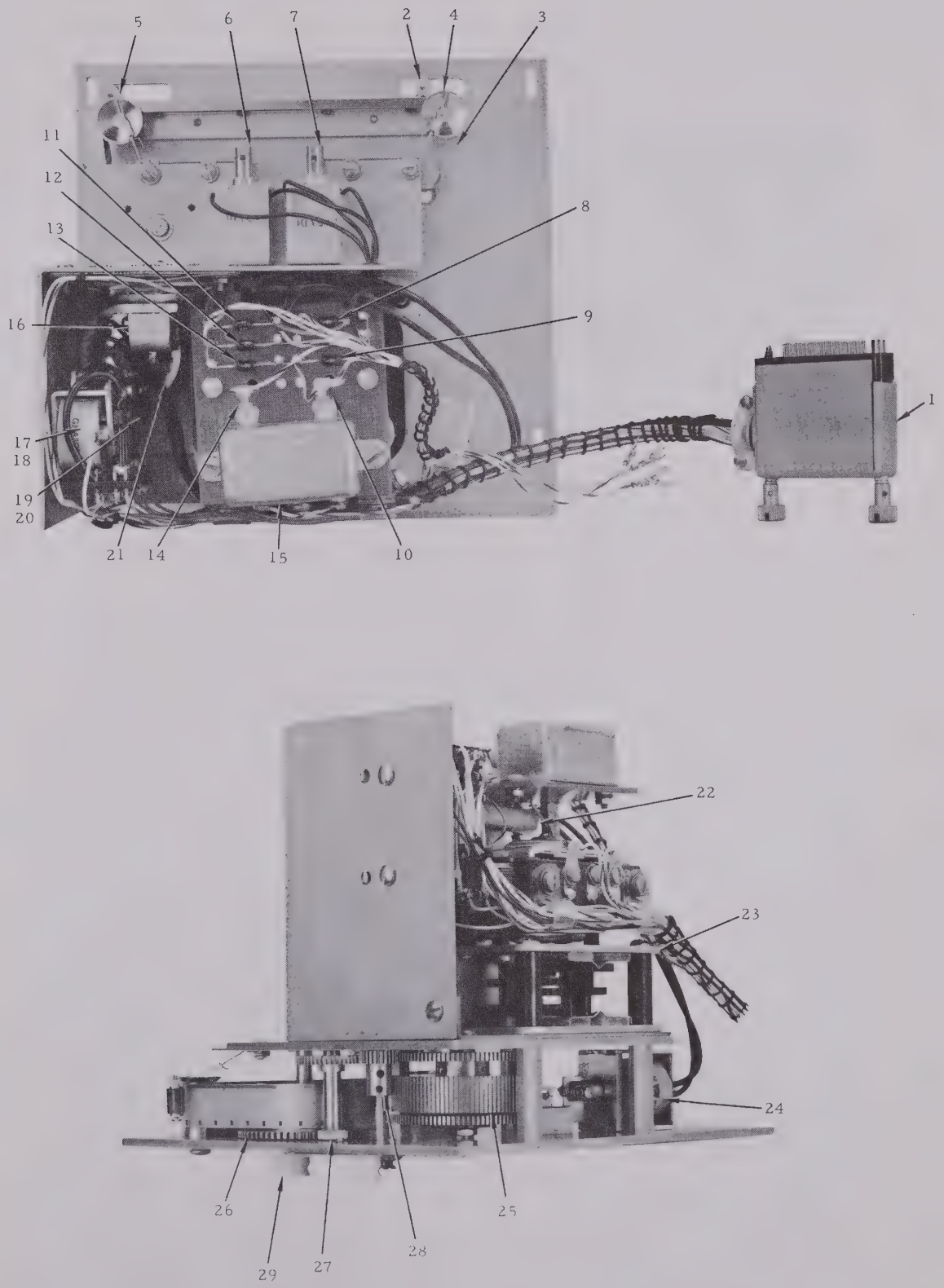


Figure 7-6. Servo Assembly

INDEX NO.	SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
-14	CR106	Diode	Semtech	SC-2
-15	C101	Capacitor, paper, 1 mfd, 400 vdc	Aerovox	P30ZN12
-16	LS101	Speaker	Guam	22A06Z-100
-17	K102	Relay, 3 PDT	Advance	GHA3C24VDC
-18	CR102	Diode	Semtech	SC-2
-19	K101	Relay, DPDT	Advance	GHA2C24VDC
-20	CR101	Diode	Semtech	SC-2
-21	B101	Resolver	Eclipse Pioneer	AY251-S-39B
-22	C102	Capacitor, paper, 2 uf, 200 vdc	Hopkins	2P2M
-23	B102	Motor, servo	Gertsch	SC322
-24	L101	Solenoid, 115 vdc, No. 28 contact	Guardian	28DC-2300-C-115
-25		Gear Assembly, planetary	Gertsch	SK824
-26		Sprocket and Gear Assembly	Gertsch	AA1008
-27		Idler Gear Assembly	Gertsch	SK857-2
-28		Counter Drive Assembly	Gertsch	SK887
-29		Guide, chain	Gertsch	OM1159

STANDARD INPUT BOARD ASSEMBLY
(See figure 7-7)

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
C201	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C202	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C203	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C204	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C205	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aervox	P8292ZN6
C206	Capacitor, electrolytic, 20 uf, 15 vdcw	Sprague	TE1157
C207	Capacitor, polystyrene, 0.0015 uf ±5%	Westcap	WR94J1152
C208	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C209	Capacitor, mica, 180 pf ±2%	Elmenco	DM15E181G
C210	Capacitor, metallized paper, 0.1 uf, 200 vdcw	Aerovox	P8292ZN10
C211	Capacitor, electrolytic, 20 uf, 15 vdcw	Sprague	TE1157
C212	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C213	Capacitor, mica, 330 pf ±5%	Elmenco	DM15E331J
C214	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C215	Capacitor, metallized paper, 0.1 uf, 200 vdcw	Aerovox	P8292ZN10
C216	Capacitor, electrolytic, 20 uf, 15 vdcw	Sprague	TE1157
C217	Capacitor, mica, 150 pf ± 2%	Elmenco	DM15E151G
CR201	Diode, germanium, 100 ma	Transitron	1N273
CR202	Diode, germanium, 100 ma	Transitron	1N273
CR203	Diode, germanium, 100 ma	Transitron	1N273
CR204	Diode, germanium, 100 ma	Transitron	1N273
L201	Inductor, adjustable, 100 mh	Gertsch	TA334
Q201	Transistor	Philco	2N1790
Q202	Transistor, PNP, germanium	Philco	2N2374
Q203	Transistor, PNP, germanium	Philco	2N2374
Q204	Transistor, PNP, germanium	Philco	2N2374
Q205	Transistor, PNP, germanium	Philco	2N2374
Q206	Transistor, PNP, germanium	Philco	2N2374

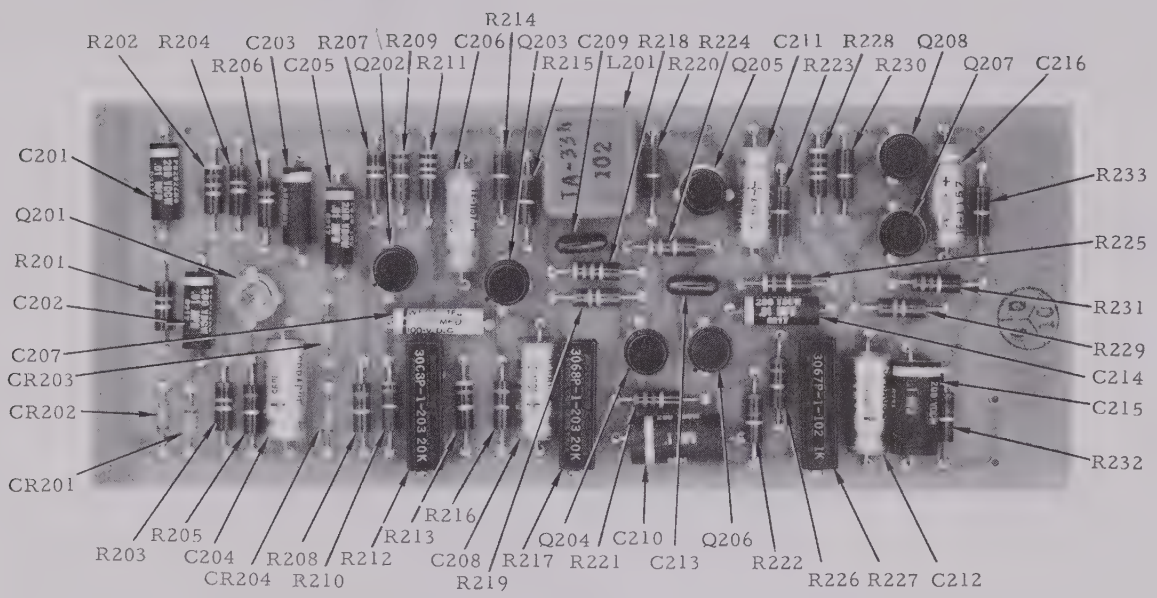


Figure 7-7. Standard Input Board Assembly

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
Q207	Transistor, PNP, germanium	Philco	2N2374
Q208	Transistor, PNP, germanium	Philco	2N2374
R201	Resistor, composition, 10K ±10%, 1/2W		
R202	Resistor, composition, 47K ±10%, 1/2W		
R203	Resistor, composition, 10K ±10%, 1/2W		
R204	Resistor, composition, 10K ±10%, 1/2W		
R205	Resistor, composition, 2.7K ±10%, 1/2W		
R206	Resistor, composition, 10K ±10%, 1/2W		
R207	Resistor, composition, 10K ±10%, 1/2W		
R208	Resistor, composition, 2.7K ±10%, 1/2W		
R209	Resistor, composition, 6.8K ±10%, 1/2W		
R210	Resistor, composition, 6.8K ±10%, 1/2W		
R211	Resistor, composition, 33K ±10%, 1/2W		
R212	Resistor, E-Z-Trim, 20K	Bourns	3068P-1-203
R213	Resistor, composition, 4.7K ±10%, 1/2W		
R214	Resistor, composition, 1.2K ±10%, 1/2W		
R215	Resistor, composition, 8.2K ±10%, 1/2W		
R216	Resistor, composition, 5.6K ±10%, 1/2W		
R217	Resistor, E-Z-Trim, 20K	Bourns	3068P-1-203
R218	Resistor, composition, 47K ±10%, 1/2W		
R219	Resistor, composition, 12K ±10%, 1/2W		

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
R220	Resistor, composition, 2.2K ±10%, 1/2W		
R221	Resistor, composition, 180 ohms ±10%, 1/2W		
R222	Resistor, composition, 820 ohms ±10%, 1/2W		
R223	Resistor, composition, 1.5K ±10%, 1/2W		
R224	Resistor, composition, 3.3K ±10%, 1/2W		
R225	Resistor, composition, 4.7K ±10%, 1/2W		
R226	Resistor, composition, 1.8K ±10%, 1/2W		
R227	Resistor, E-Z-Trim, 1K	Bourns	3067P-1-102
R228	Resistor, composition, 47K ±10%, 1/2W		
R229	Resistor, composition, 12K ±10%, 1/2W		
R230	Resistor, composition, 2.2K ±10%, 1/2W		
R231	Resistor, composition, 180 ohms ±10%, 1/2W		
R232	Resistor, composition, 820 ohms ±10%, 1/2W		
R233	Resistor, composition, 1.5K ±10%, 1/2W		

RESOLVER OUTPUT BOARD ASSEMBLY
(See figure 7-8)

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
C301	Capacitor, metallized paper, 0.1 uf, 200 vdcw	Aerovox	P8292ZN10
C302	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C303	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C304	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C305	Capacitor, electrolytic, 25 uf, 25 vdcw	Sprague	TE1207
C306	Capacitor, polystyreme, 0.015 ±5%, 100 vdcw	Westcap	WR94J1153
C307	Capacitor, metallized paper, 0.1 uf, 200 vdcw	Aerovox	P8292ZN10
C308	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
CR301	Diode, germanium, 100 ma	Transitron	1N273
CR302	Diode, germanium, 100 ma	Transitron	1N273
Q301	Transitron, PNP, germanium	Philco	2N2374
Q302	Transitron, PNP, germanium	Philco	2N2374
Q303	Transistron, PNP, germanium	Philco	2N2374
R301	Resistor, composition, 1.5K ±10%, 1/2W		
R302	Resistor, composition, 8.2K ±10%, 1/2W		
R303	Resistor, composition, 22K ±10%, 1/2W		
R304	Resistor, composition, 33K ±10%, 1/2W		
R305	Resistor, composition, 10K ±10%, 1/2W		
R306	Resistor, composition, 10K ±10%, 1/2W		
R307	Resistor, composition, 2.7K ±10%, 1/2W		
R308	Resistor, composition, 6.8K ±10%, 1/2W		
R309	Resistor, composition, 6.8K ±10%, 1/2W		
R310	Resistor, composition, 33K ±10%, 1/2W		
R311	Resistor, E-Z-Trim, 20K	Bourns	3068P-1-203
R312	Resistor, composition, 4.7K ±10%, 1/2W		
R313	Resistor, composition, 1.2K ±10%, 1/2W		

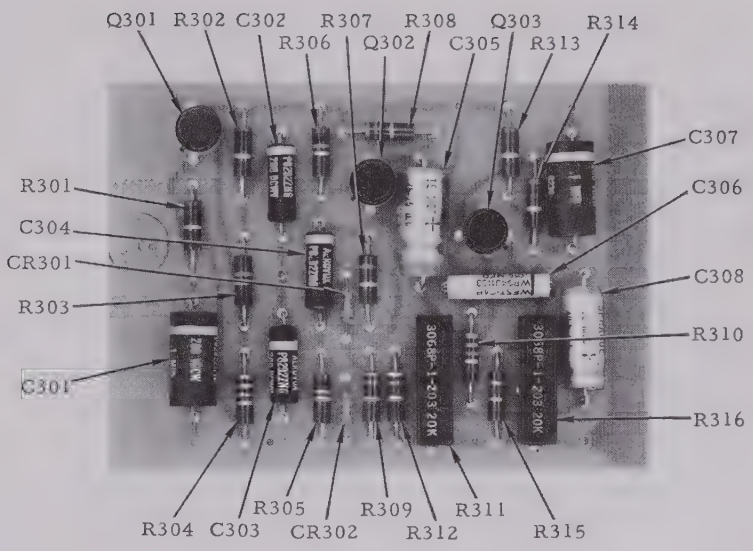


Figure 7-8. Resolver Output Board Assembly

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
R314	Resistor, composition, 8.2K ±10%, 1/2W		
R315	Resistor, composition, 5.6K ±10%, 1/2W		
R316	Resistor, E-Z-Trim, 20K	Bourns	3068P-1-203

10 KC TO 1 KC DIVIDER BOARD ASSEMBLY
(See figure 7-9)

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
C401	Capacitor, electrolytic, 20 uf, 15 vdcw	Sprague	TE1157
C402	Capacitor, polystyreme, 0.22 uf ±5%, 100 vdcw	Westcap	WR94J1224
C403	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
Q401	Transistor, PNP, germanium	Philco	2N2374
Q402	Transistor, PNP, germanium	Philco	2N2374
R401	Resistor, composition, 5.6K ±10%, 1/2W		
R402	Resistor, composition, 10K ±10%, 1/2W		
R403	Resistor, composition, 2.7K ±10%, 1/2W		
R404	Resistor, composition, 6.8K ±10%, 1/2W		
R405	Resistor, composition, 6.8K ±10%, 1/2W		

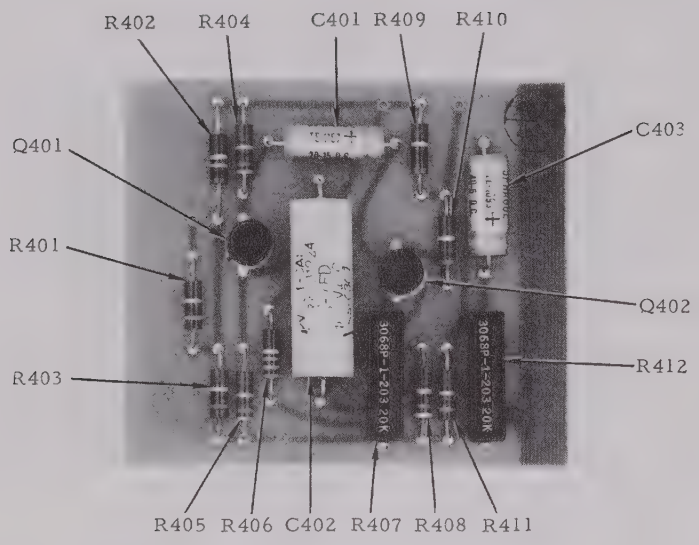


Figure 7-9. 10 KC to 1 KC Divider Board Assembly

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
R406	Resistor, composition, 33K ±10%, 1/2W		
R407	Resistor, E-Z-Trim, 20K	Bourns	3068P-1-203
R408	Resistor, composition, 4.7K ±10%, 1/2W		
R409	Resistor, composition, 1.2K ±10%, 1/2W		
R410	Resistor, composition, 8.2K ±10%, 1/2W		
R411	Resistor, composition, 5.6K ±10%, 1/2W		
R412	Resistor, E-Z-Trim, 20K	Bourns	3068P-1-203

1 KC TO 0.2 KC DIVIDER BOARD ASSEMBLY
(See figure 7-10)

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
C501	Capacitor, metallized paper, 0.5 uf, 200 vdcw	Aerovox	P8292ZN12
C502	Capacitor, electrolytic, 50 uf, 15 vdcw	Sprague	TE1160
C503	Capacitor, mylar, 1.0 uf ±10%, 100 vdcw	Westcap	WF68K1105
C504	Capacitor, electrolytic, 100 uf, 6 vdcw	Sprague	TE1102
Q501	Transistor, PNP, germanium	Philco	2N2374
Q502	Transistor, PNP, germanium	Philco	2N2374
R501	Resistor, composition, 5.6K ±10%, 1/2W		

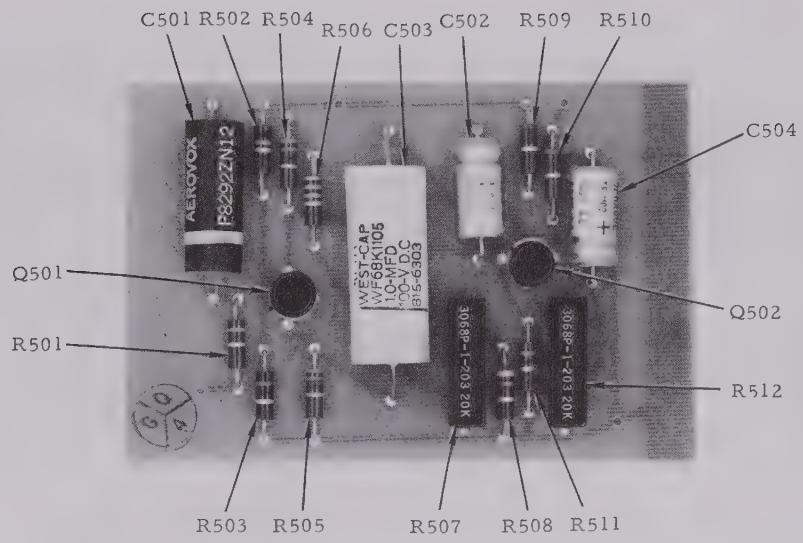


Figure 7-10. 1 KC to 0.2 KC Divider Board Assembly

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
R502	Resistor, composition, 10K ±10%, 1/2W		
R503	Resistor, composition, 2.7K ±10%, 1/2W		
R504	Resistor, composition, 6.8K ±10%, 1/2W		
R505	Resistor, composition, 6.8K ±10%, 1/2W		
R506	Resistor, composition, 33K ±10%, 1/2W		
R507	Resistor, E-Z-Trim, 20K	Bourns	3068P-1-203
R508	Resistor, composition, 4.7K ±10%, 1/2W		
R509	Resistor, composition, 1.2K ±10%, 1/2W		
R510	Resistor, composition, 8.2K ±10%, 1/2W		
R511	Resistor, composition, 5.6K ±10%, 1/2W		
R512	Resistor, E-Z-Trim, 20K	Bourns	3068P-1-203

DOUBLER MIXER BOARD ASSEMBLY
(See figure 7-11)

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
C601	Capacitor, metallized paper, 0.1 uf, 200 vdcw	Aerovox	P8292ZN10
C602	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C603	Capacitor, metallized paper, 0.1 uf, 200 vdcw	Aerovox	P8292ZN10

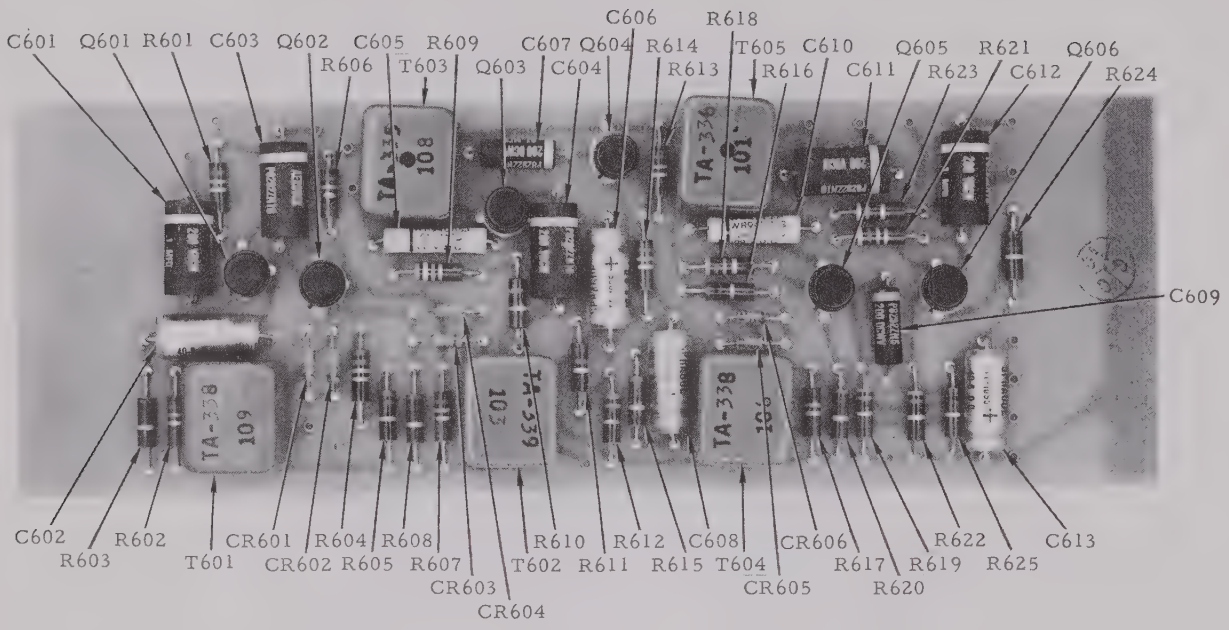


Figure 7-11. Doubler Mixer Board Assembly

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
C604	Capacitor, metallized paper, 0.1 uf, 200 vdcw	Aerovox	P8292ZN10
C605	Capacitor, polystyrene, 0.015 uf ±5%, 100 vdcw	Westcap	WR94J1153
C606	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C607	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C608	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C609	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C610	Capacitor, polystyrene, 0.0015 uf ±5%, 100 vdcw	Westcap	WR94J1152
C611	Capacitor, metallized paper, 0.1 uf, 200 vdcw	Aerovox	P8292ZN10
C612	Capacitor, metallized paper, 0.1 uf, 200 vdcw	Aerovox	P8292ZN10
C613	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
CR601	Diode, germanium, 100 ma	Transitron	1N273
CR602	Diode, germanium, 100 ma	Transitron	1N273
CR603	Diode, germanium, 100 ma	Transitron	1N273
CR604	Diode, germanium, 100 ma	Transitron	1N273
CR605	Diode, germanium, 100 ma	Transitron	1N273
CR606	Diode, germanium, 100 ma	Transitron	1N273
Q601	Transistor, PNP, germanium	Philco	2N2374
Q602	Transistor, PNP, germanium	Philco	2N2374
Q603	Transistor, PNP, germanium	Philco	2N2374
Q604	Transistor, PNP, germanium	Philco	2N2374
Q605	Transistor, PNP, germanium	Philco	2N2374

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
Q606	Transistor, PNP, germanium	Philco	2N2374
R601	Resistor, composition, 27K ±10%, 1/2W		
R602	Resistor, composition, 27K ±10%, 1/2W		
R603	Resistor, composition, 1.5K ±10%, 1/2W		
R604	Resistor, composition, 4.7K±10%, 1/2W		
R605	Resistor, composition, 1.5K ±10%, 1/2W		
R606	Resistor, composition, 27K ±10%, 1/2W		
R607	Resistor, composition, 27K ±10%, 1/2W		
R608	Resistor, composition, 1.5K ±10%, 1/2W		
R609	Resistor, composition, 39K ±10%, 1/2W		
R610	Resistor, composition, 2.7K ±10%, 1/2W		
R611	Resistor, composition, 220 ohms ±10%, 1/2W		
R612	Resistor, composition, 1.8K ±10%, 1/2W		
R613	Resistor, composition, 27K ±10%, 1/2W		
R614	Resistor, composition, 27K ±10%, 1/2W		
R615	Resistor, composition, 1.5K ±10%, 1/2W		
R616	Resistor, composition, 1K ±10%, 1/2W		
R617	Resistor, composition, 22K ±10%, 1/2W		
R618	Resistor, composition, 47K ±10%, 1/2W		
R619	Resistor, composition, 6.8K ±10%, 1/2W		
R620	Resistor, composition, 1.5K ±10%, 1/2W		
R621	Resistor, composition, 47K ±10%, 1/2W		
R622	Resistor, composition, 6.8K ±10%, 1/2W		
R623	Resistor, composition, 4.7K %10%, 1/2W		
R624	Resistor, composition, 100 ohms ±10%, 1/2W		
R625	Resistor, composition, 1K ±10%, 1/2W		
T601	Transformer	Gertsch	TA338
T602	Transformer	Gertsch	TA339
T603	Transformer	Gertsch	TA335
T604	Transformer	Gertsch	TA361
T605	Transformer	Gertsch	TA336

COMPARE INPUT BOARD ASSEMBLY
(See figure 7-12)

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
C701	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C702	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C703	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C704	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C705	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C706	Capacitor, electrolytic, 20 uf, 15 vdcw	Sprague	TE1157
C707	Capacitor, polystyrene, 0.0015 uf, 100 vdcw	Westcap	WR94J1152
C708	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C709	Capacitor, mica, 150 pf ±2%	Elmenco	DM15E151G
CR701	Diode, germanium, 100ma	Transitron	1N273

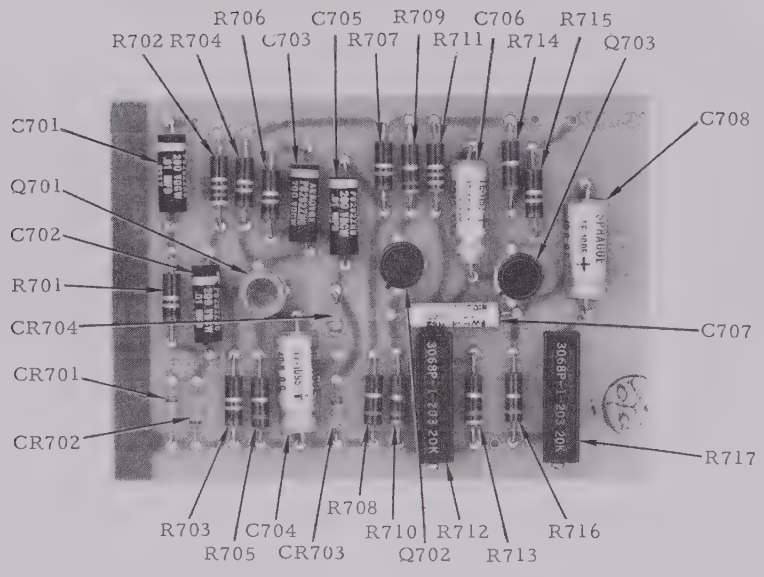


Figure 7-12. Compare Input Board Assembly

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
CR702	Diode, germanium, 100 ma	Transitron	1N273
CR703	Diode, germanium, 100 ma	Transitron	1N273
CR704	Diode, germanium, 100 ma	Transitron	1N273
Q701	Transistor	Philco	2N1790
Q702	Transistor, PNP, germanium	Philco	2N2374
Q703	Transistor, PNP, germanium	Philco	2N2374
R701	Resistor, composition, 10K ±10%, 1/2W		
R702	Resistor, composition, 47K ±10%, 1/2W		
R703	Resistor, composition, 10K ±10%, 1/2W		
R704	Resistor, composition, 10K ±10%, 1/2W		
R705	Resistor, composition, 2.7K ±10%, 1/2W		
R706	Resistor, composition, 10K ±10%, 1/2W		
R707	Resistor, composition, 10K ±10%, 1/2W		
R708	Resistor, composition, 2.7K ±10%, 1/2W		
R709	Resistor, composition, 6.8K ±10%, 1/2W		
R710	Resistor, composition, 6.8K ±10%, 1/2W		
R711	Resistor, composition, 33K ±10%, 1/2W		
R712	Resistor, E-Z-Trim, 20K	Bourns	3068P-1-203
R713	Resistor, composition, 4.7K ±10%, 1/2W		
R714	Resistor, composition, 470 ohms ±10%, 1/2W		

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
R715	Resistor, composition, 10K ±10%, 1/2W		
R716	Resistor, composition, 5.6K ±10%, 1/2W		
R717	Resistor, E-Z-Trim, 20K	Bourns	3068P-1-203

PHASE DETECTOR BOARD ASSEMBLY
(See figure 7-13)

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
C801	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C802	Capacitor, metallized paper, 0.1 uf, 200 vdcw	Aerovox	P8292ZN10
C803	Capacitor, electrolytic, 500 uf, 3 vdcw	Sprague	TE1068
C804	Capacitor, metallized paper, 0.1 uf, 200 vdcw	Aerovox	P8292ZN10
C805	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C806	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C807	Capacitor, mica, 330 pf ±5%, 300 vdcw	Elmenco	DM15E331J
C808	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C809	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C810	Capacitor, metallized paper, 0.1 uf, 200 vdcw	Aerovox	P8292ZN10
C811	Capacitor, electrolytic, 150 uf, 6 vdcw	Sprague	TE1103
C812	Capacitor, metallized paper, 0.1 uf, 200 vdcw	Aerovox	P8292ZN10
Q801	Transistor, PNP, germanium	Philco	2N2374
Q802	Transistor, PNP, germanium	Philco	2N2374
Q803	Transistor, PNP, germanium	Philco	2N2374
Q804	Transistor, PNP, germanium	Philco	2N2374
Q805	Transistor, PNP, germanium	Philco	2N2374
Q806	Transistor, PNP, germanium	Philco	2N2374
Q807	Transistor, PNP, germanium	Philco	2N2374
Q808	Transistor, PNP, germanium	Philco	2N2374
Q809	Transistor, PNP, germanium	Philco	2N2374
R801	Resistor, composition, 27K ±10%, 1/2W		
R802	Resistor, composition, 27K ±10%, 1/2W		
R803	Resistor, composition, 1.5K ±10%, 1/2W		
R804	Resistor, composition, 33K ±10%, 1/2W		
R805	Resistor, composition, 2.7K ±10%, 1/2W		
R806	Resistor, composition, 1K ±10%, 1/2W		
R807	Resistor, composition, 1K ±10%, 1/2W		
R808	Resistor, composition, 680 ohms ±10%, 1/2W		
R809	Resistor, composition, 1.5K ±10%, 1/2W		
R810	Resistor, composition, 27K ±10%, 1/2W		
R811	Resistor, composition, 27K ±10%, 1/2W		
R812	Resistor, composition, 47K ±10%, 1/2W		
R813	Resistor, composition, 4.7K ±10%, 1/2W		
R814	Resistor, composition, 3.3K ±10%, 1/2W		
R815	Resistor, composition, 4.7K ±10%, 1/2W		
R816	Resistor, composition, 560 ohms ±10%, 1/2W		
R817	Resistor, composition, 470 ohms ±10%, 1/2W		

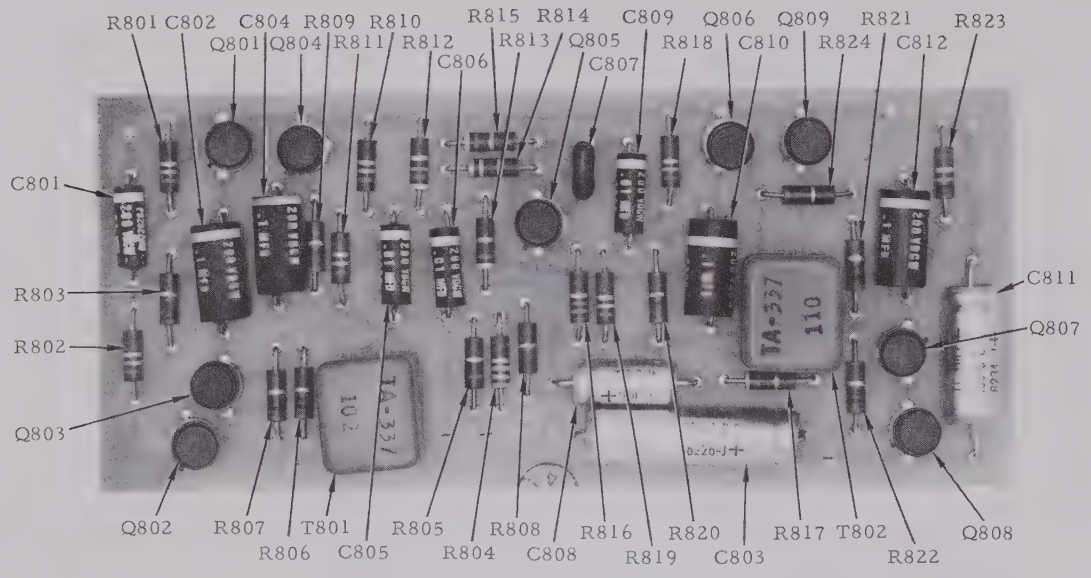


Figure 7-13. Phase Detector Board Assembly

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
R818	Resistor, composition, 27K ±10%, 1/2W		
R819	Resistor, composition, 27K ±10%, 1/2W		
R820	Resistor, composition, 1.5K ±10%, 1/2W		
R821	Resistor, composition, 1K ±10%, 1/2W		
R822	Resistor, composition, 1K ±10%, 1/2W		
R823	Resistor, composition, 10K ±10%, 1/2W		
R824	Resistor, composition, 1.5K ±10%, 1/2W		
T801	Transformer	Gertsch	TA337
T802	Transformer	Gertsch	TA337

SERVO AMPLIFIER BOARD ASSEMBLY
(See figure 7-14)

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
C901	Capacitor, electrolytic, 10 uf, 25 vdcw	Sprague	TE1204
C902	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C903	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C904	Capacitor, electrolytic, 50 uf, 15 vdcw	Sprague	TE1160
C905	Capacitor, electrolytic, 10 uf, 25 vdcw	Sprague	TE1204

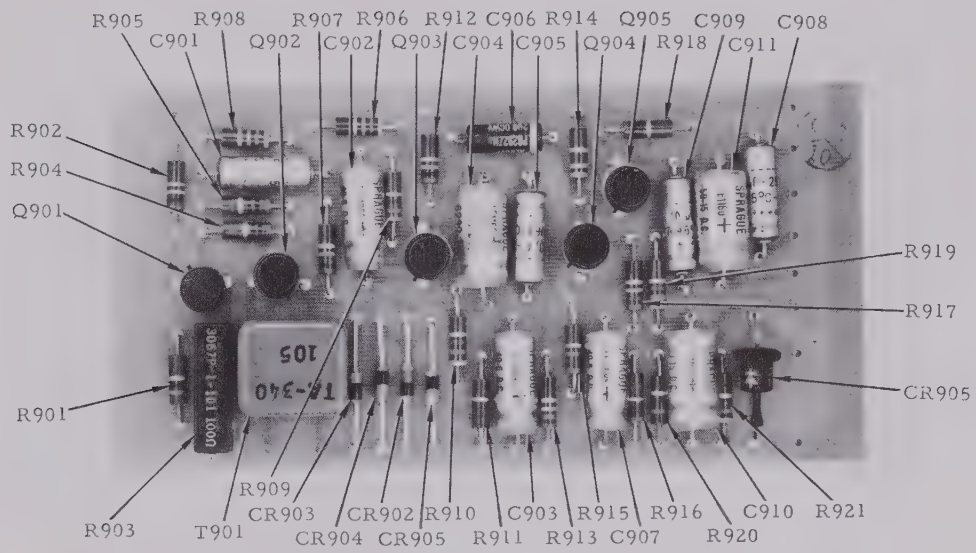


Figure 7-14. Servo Amplifier Board Assembly

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
C906	Capacitor, metallized paper, 0.05 uf, 200 vdcw	Aerovox	P8292ZN9
C907	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C908	Capacitor, electrolytic, 10 uf, 25 vdcw	Sprague	TE1204
C909	Capacitor, electrolytic, 10 uf, 25 vdcw	Sprague	TE1204
C910	Capacitor, electrolytic, 50 uf, 15 vdcw	Sprague	TE1160
C911	Capacitor, electrolytic, 50 uf, 15 vdcw	Sprague	TE1160
CR901	Diode	Semtech	SC-2
CR902	Diode	Semtech	SC-2
CR903	Diode	Semtech	SC-2
CR904	Diode	Semtech	SC-2
CR905	Diode	General Electric	1N91
Q901	Transistor, PNP, germanium	Philco	2N2374
Q902	Transistor, PNP, germanium	Philco	2N2374
Q903	Transistor, PNP, germanium	Philco	2N2374
Q904	Transistor, PNP, germanium	Philco	2N2374
Q905	Transistor, PNP, germanium	Philco	2N2374
R901	Resistor, composition, 22 ohms ±10%, 1/2W		
R902	Resistor, composition, 100K ±10%, 1/2W		
R903	Resistor, E-Z-Trim, 100 ohms	Bourns	3067P-1-101
R904	Resistor, composition, 1K ±10%, 1/2W		
R905	Resistor, composition, 1K ±10%, 1/2W		
R906	Resistor, composition, 47K ±10%, 1/2W		

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
R907	Resistor, composition, 10K ±10%, 1/2W		
R908	Resistor, composition, 10K ±10%, 1/2W		
R909	Resistor, composition, 6.8K ±10%, 1/2W		
R910	Resistor, composition, 470 ohms ±10%, 1/2W		
R911	Resistor, composition, 2.2K ±10%, 1/2W		
R912	Resistor, composition, 10K ±10%, 1/2W		
R913	Resistor, composition, 18K ±10%, 1/2W		
R914	Resistor, composition, 3.3K ±10%, 1/2W		
R915	Resistor, composition, 150 ohms ±10%, 1/2W		
R916	Resistor, composition, 1.2K ±10%, 1/2W		
R917	Resistor, composition, 15K ±10%, 1/2W		
R918	Resistor, composition, 1K ±10%, 1/2W		
R919	Resistor, composition, 470 ohms ±10%, 1/2W		
R920	Resistor, composition, 2.7K ±10%, 1/2W		
R921	Resistor, composition, 4.7K ±10%, 1/2W		

AGC AMPLIFIER BOARD ASSEMBLY
(See figure 7-15)

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
C1001	Capacitor, electrolytic, 10 uf, 25 vdcw	Sprague	TE1204
C1002	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C1003	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C1004	Capacitor, electrolytic, 10 uf, 25 vdcw	Sprague	TE1204
C1005	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C1006	Capacitor, electrolytic, 10 uf, 25 vdcw	Sprague	TE1204
C1007	Capacitor, electrolytic, 10 uf, 25 vdcw	Sprague	TE1204
C1008	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C1009	Capacitor, electrolytic, 500 uf, 3 vdcw	Sprague	TE1068
C1010	Capacitor, electrolytic, 500 uf, 3 vdcw	Sprague	TE1068
CR1001	Diode, germanium, 100 ma	Transitron	1N273
CR1002	Diode, germanium, 100 ma	Transitron	1N273
CR1003	Diode, germanium, 100 ma	Transitron	1N273
CR1004	Diode, germanium, 100 ma	Transitron	1N273
CR1005	Diode, germanium, 100 ma	Transitron	1N273
Q1001	Transistor, PNP, germanium	Philco	2N2374
Q1002	Transistor, PNP, germanium	Philco	2N2374
Q1003	Transistor, PNP, germanium	Philco	2N2374
Q1004	Transistor, PNP, germanium	Philco	2N2374
Q1005	Transistor, PNP, germanium	Philco	2N2374
R1001	Resistor, composition, 100K ±10%, 1/2W		
R1002	Resistor, composition, 1K ±10%, 1/2W		
R1003	Resistor, composition, 1K ±10%, 1/2W		
R1004	Resistor, composition, 47K ±10%, 1/2W		
R1005	Resistor, composition, 15K ±10%, 1/2W		
R1006	Resistor, composition, 47K ±10%, 1/2W		

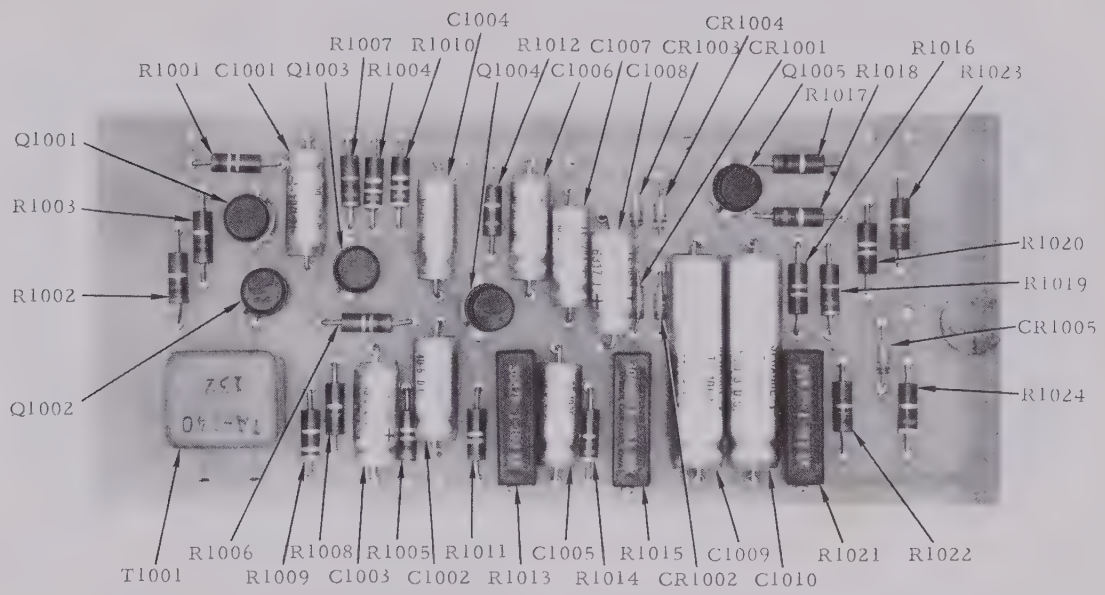


Figure 7-15. AGC Amplifier Board Assembly

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
R1007	Resistor, composition, 6.8K ±10%, 1/2W		
R1008	Resistor, composition, 470 ohms ±10%, 1/2W		
R1009	Resistor, composition, 2.2K ±10%, 1/2W		
R1010	Resistor, composition, 47K ±10%, 1/2W		
R1011	Resistor, composition, 12K ±10%, 1/2W		
R1012	Resistor, composition, 2.7K ±10%, 1/2W		
R1013	Resistor, E-Z-Trim, 1K	Bourns	3067P-1-102
R1014	Resistor, composition, 470 ohms ±10%, 1/2W		
R1015	Resistor, E-Z-Trim, 20K	Bourns	3068P-1-203
R1016	Resistor, composition, 22K ±10%, 1/2W		
R1017	Resistor, composition, 1K ±10%, 1/2W		
R1018	Resistor, composition, 27 ohms ±10%, 1/2W		
R1019	Resistor, composition, 6.8K ±10%, 1/2W		
R1020	Resistor, composition, 22K ±10%, 1/2W		
R1021	Resistor, E-Z-Trim, 1K	Bourns	3067P-1-102
R1022	Resistor, composition, 100 ohms ±10%, 1/2W		
R1023	Resistor, composition, 220 ohms ±10%, 1/2W		
R1024	Resistor, composition, 4.7K ±10%, 1/2W		
T1001	Transformer	Gertsch	TA340

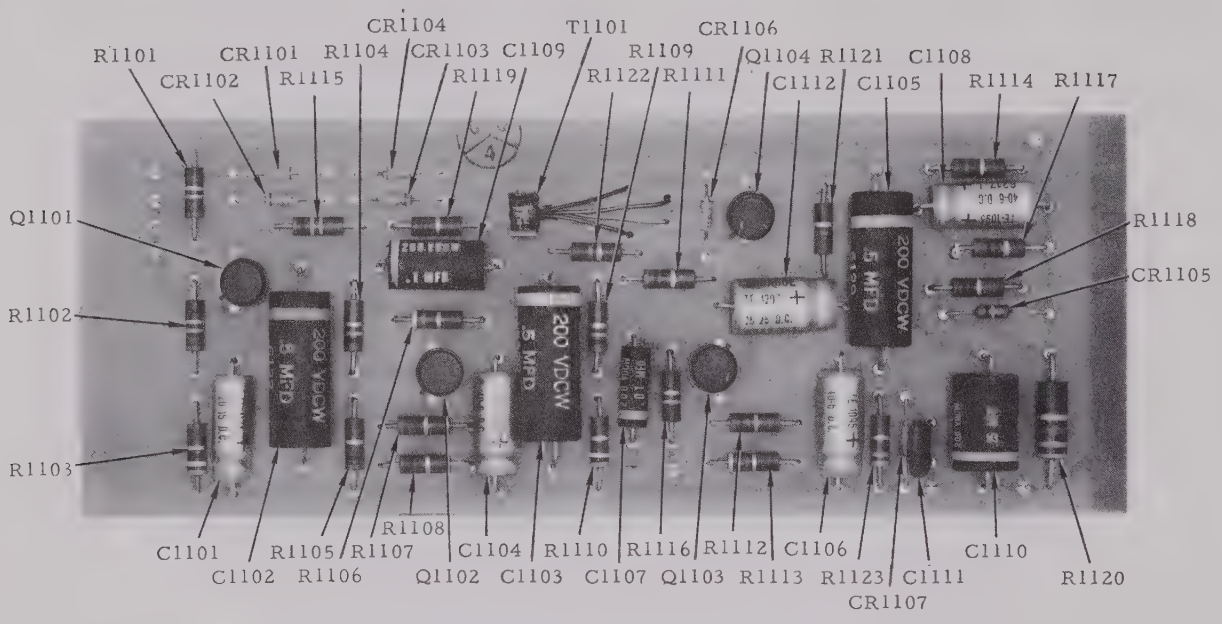


Figure 7-16. Locked Oscillator Board Assembly

LOCKED OSCILLATOR BOARD ASSEMBLY
(See figure 7-16)

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
C1101	Capacitor, electrolytic, 20 uf, 15 vdcw	Sprague	TE1157
C1102	Capacitor, metallized paper, 0.5 uf, 200 vdcw	Aerovox	P8292ZN12
C1103	Capacitor, metallized paper, 0.5 uf, 200 vdcw	Aerovox	P8292ZN12
C1104	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C1105	Capacitor, metallized paper, 0.5 uf, 200 vdcw	Aerovox	P8292ZN12
C1106	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C1107	Capacitor, metallized paper, 0.014 uf, 200 vdcw	Aerovox	P8292ZN6
C1108	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C1109	Capacitor, metallized paper, 0.1 uf, 200 vdcw	Aerovox	P8292ZN10
C1110	Capacitor, metallized paper, 0.5 uf, 200 vdcw	Hopkins	P52D
C1111	Capacitor, mica, 180 pf ±5%, 300 vdcw	Elmenco	DM15E181J
C1112	Capacitor, electrolytic, 25 uf, 25 vdcw	Sprague	TE1207
CR1101	Diode, germanium, 100 ma		1N273
CR1102	Diode, germanium, 100 ma		1N273
CR1103	Diode, germanium, 100 ma		1N273
CR1104	Diode, germanium, 100 ma		1N273
CR1105	Diode, zener		1N709
CR1106	Diode, germanium, 100 ma		1N273
CR1107	Diode, germanium, 100 ma		1N273

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
Q1101	Transistor, PNP, germanium	Philco	2N2374
Q1102	Transistor, PNP, germanium	Philco	2N2374
Q1103	Transistor, PNP, germanium	Philco	2N2374
Q1104	Transistor, PNP, germanium	Philco	2N2374
R1101	Resistor, composition, 15K ±10%, 1/2W		
R1102	Resistor, composition, 15K ±10%, 1/2W		
R1103	Resistor, composition, 3.9K ±10%, 1/2W		
R1104	Resistor, composition, 10K ±10%, 1/2W		
R1105	Resistor, composition, 1K ±10%, 1/2W		
R1106	Resistor, composition, 4.7K ±10%, 1/2W		
R1107	Resistor, composition, 82 ohms ±10%, 1/2W		
R1108	Resistor, composition, 1K ±10%, 1/2W		
R1109	Resistor, composition, 10K ±10%, 1/2W		
R1110	Resistor, composition, 3.9K ±10%, 1/2W		
R1111	Resistor, composition, 1K ±10%, 1/2W		
R1112	Resistor, composition, 100 ohms ±10%, 1/2W		
R1113	Resistor, composition, 470 ohms ±10%, 1/2W		
R1114	Resistor, composition, 1.8K ±10%, 1/2W		
R1115	Resistor, composition, 100K ±10%, 1/2W		
R1116	Resistor, composition, 22K ±10%, 1/2W		
R1117	Resistor, composition, 1K ±10%, 1/2W		
R1118	Resistor, composition, 1K ±10%, 1/2W		
R1119	Resistor, composition, 2.2K ±10%, 1/2W		
R1120	Resistor, composition, 330 ohms ±10%, 1W		
R1121	Resistor, composition, 220 ohms ±10%, 1/2W		
R1122	Resistor, composition, 220 ohms ±10%, 1/2W		
R1123	Resistor, composition, 3.3K ±10%, 1/2W		
T1101	Transformer	UTC	PIP-6

SHIFT AND LOCKOUT BOARD ASSEMBLY
(See figure 7-17)

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
C1201	Capacitor, electrolytic, 10 uf, 25 vdcw	Sprague	TE1204
C1202	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C1203	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C1204	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
C1205	Capacitor, electrolytic, 40 uf, 6 vdcw	Sprague	TE1095
CR1201	Diode, germanium, 100 ma		1N273
CR1202	Diode, germanium, 100 ma		1N273
CR1203	Diode, germanium, 100 ma		1N273
CR1204	Diode, germanium, 100 ma		1N273
Q1201	Transistor, PNP, germanium	Philco	2N2374
Q1202	Transistor, PNP, germanium	Philco	2N2374
Q1203	Transistor, PNP, germanium	Philco	2N2374
Q1204	Transistor, PNP, germanium	Philco	2N2374

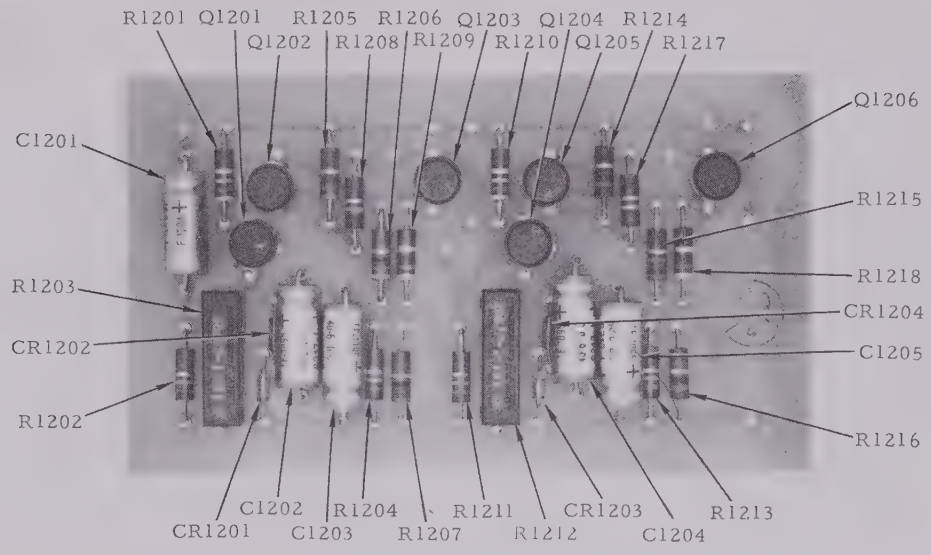


Figure 7-17. Shift and Lockout Board Assembly

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
Q1205	Transistor, PNP, germanium	Philco	2N2374
Q1206	Transistor, PNP, germanium	Philco	2N2374
R1201	Resistor, composition, 100K ±10%, 1/2W		
R1202	Resistor, composition, 15K ±10%, 1/2W		
R1203	Resistor, variable, E-Z-Trim, 1K	Bourns	3067P-1-102
R1204	Resistor, composition, 27K ±10%, 1/2W		
R1205	Resistor, composition, 6.8K ±10%, 1/2W		
R1206	Resistor, composition, 47 ohms ±10%, 1/2W		
R1207	Deleted		
R1208	Resistor, composition, 22K ±10%, 1/2W		
R1209	Resistor, composition, 4.7K ±10%, 1/2W		
R1210	Resistor, composition, 100K ±10%, 1/2W		
R1211	Resistor, composition, 15K ±10%, 1/2W		
R1212	Resistor, variable, E-Z-Trim, 1K	Bourns	3067P-1-102
R1213	Resistor, composition, 27K ±10%, 1/2W		
R1214	Resistor, composition, 2.7K ±10%, 1/2W		
R1215	Deleted		
R1216	Resistor, composition, 27 ohms ±10%, 1/2W		
R1217	Resistor, composition, 22K ±10%, 1/2W		
R1218	Resistor, composition, 4.7K ±10%, 1/2W		

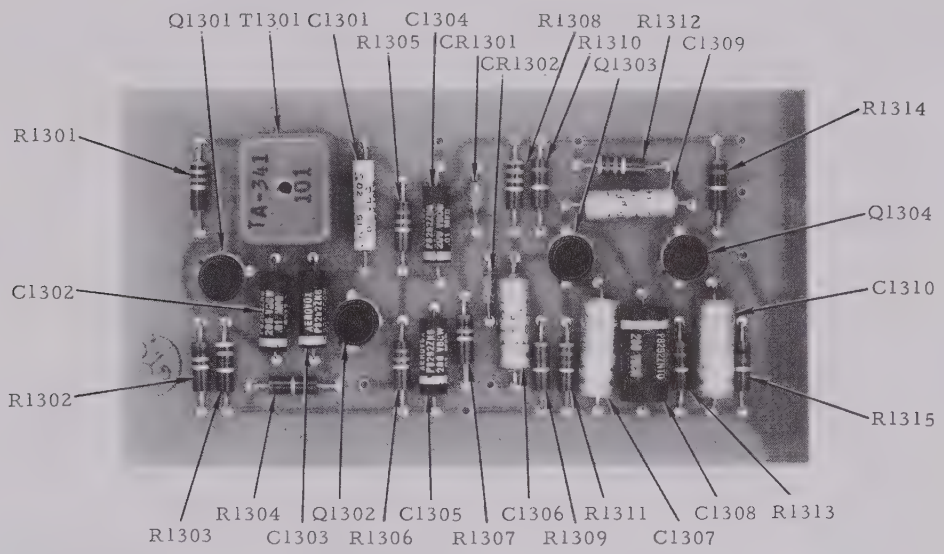


Figure 7-18. Audio Board Assembly

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
C1301	Capacitor, polystyrene, 0.0022 uf ±2%, 100 vdcw	Westcap	WR94U1222
C1302	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C1303	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C1304	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C1305	Capacitor, metallized paper, 0.01 uf, 200 vdcw	Aerovox	P8292ZN6
C1306	Capacitor, electrolytic, 10 uf, 25 vdcw	Sprague	TE1204
C1307	Capacitor, electrolytic, 25 uf, 10 vdcw	Sprague	TE1118
C1308	Capacitor, metallized paper, 0.1 uf, 200 vdcw	Aerovox	P8292ZN10
C1309	Capacitor, electrolytic, 10 uf, 25 vdcw	Sprague	TE1204
C1310	Capacitor, electrolytic, 25 uf, 10 vdcw	Sprague	TE1118
CR1301	Diode, germanium, 100 ma	Transitron	1N273
CR1302	Diode, germanium, 100 ma	Transitron	1N273
Q1301	Transistor, PNP, germanium	Philco	2N2374
Q1302	Transistor, PNP, germanium	Philco	2N2374
Q1303	Transistor, PNP, germanium	Philco	2N2374
Q1304	Transistor, PNP, germanium	Philco	2N2374
R1301	Resistor, composition, 33K ±10%, 1/2W		
R1302	Resistor, composition, 10K ±10%, 1/2W		
R1303	Resistor, composition, 4.7K ±10%, 1/2W		
R1304	Resistor, composition, 1.5K ±10%, 1/2W		
R1305	Resistor, composition, 27K ±10%, 1/2W		
R1306	Resistor, composition, 27K ±10%, 1/2W		

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
R1307	Resistor, composition, 10K ±10%, 1/2W		
R1308	Resistor, composition, 33K ±10%, 1/2W		
R1309	Resistor, composition, 8.2K ±10%, 1/2W		
R1310	Resistor, composition, 2.7K ±10%, 1/2W		
R1311	Resistor, composition, 680 ohms ±10%, 1/2W		
R1312	Resistor, composition, 47K ±10%, 1/2W		
R1313	Resistor, composition, 1.8K ±10%, 1/2W		
R1314	Resistor, composition, 1.8K ±10%, 1/2W		
R1315	Resistor, composition, 100 ohms ±10%, 1/2W		
T1301	Transformer	Gertsch	TA341

POWER SUPPLY BOARD ASSEMBLY
(See figure 7-19)

SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.
C1401	Capacitor, electrolytic, 10 uf, 25 vdcw	Sprague	TE1204
CR1401	Diode	Semtech	SC-2
CR1402	Diode	Semtech	SC-2
CR1403	Diode	Semtech	SC-2
CR1404	Diode	Semtech	SC-2
R1401	Resistor, composition, 2.7K ±10%, 1W		
R1402	Resistor, composition, 1K ±10%, 1/2W		
R1403	Resistor, composition, 2.7K ±10%, 1/2W		
R1404	Resistor, variable, E-Z-Trim, 1K	Bourns	3067P-1-102
R1405	Resistor, composition, 10K ±10%, 1/2W		
Q1401	Transistor, PNP, germanium	Philco	2N1924
Q1402	Transistor, PNP, germanium	Philco	2N2374

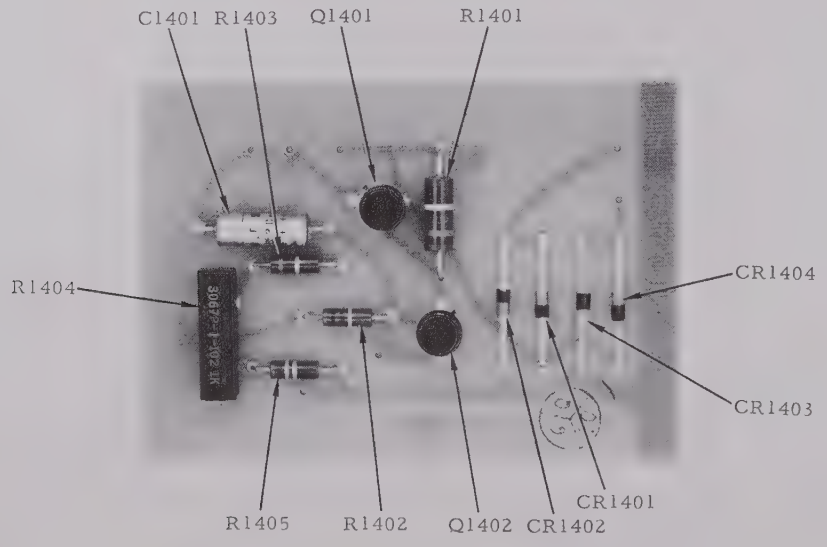


Figure 7-19. Power Supply Board Assembly

RFM MODULE

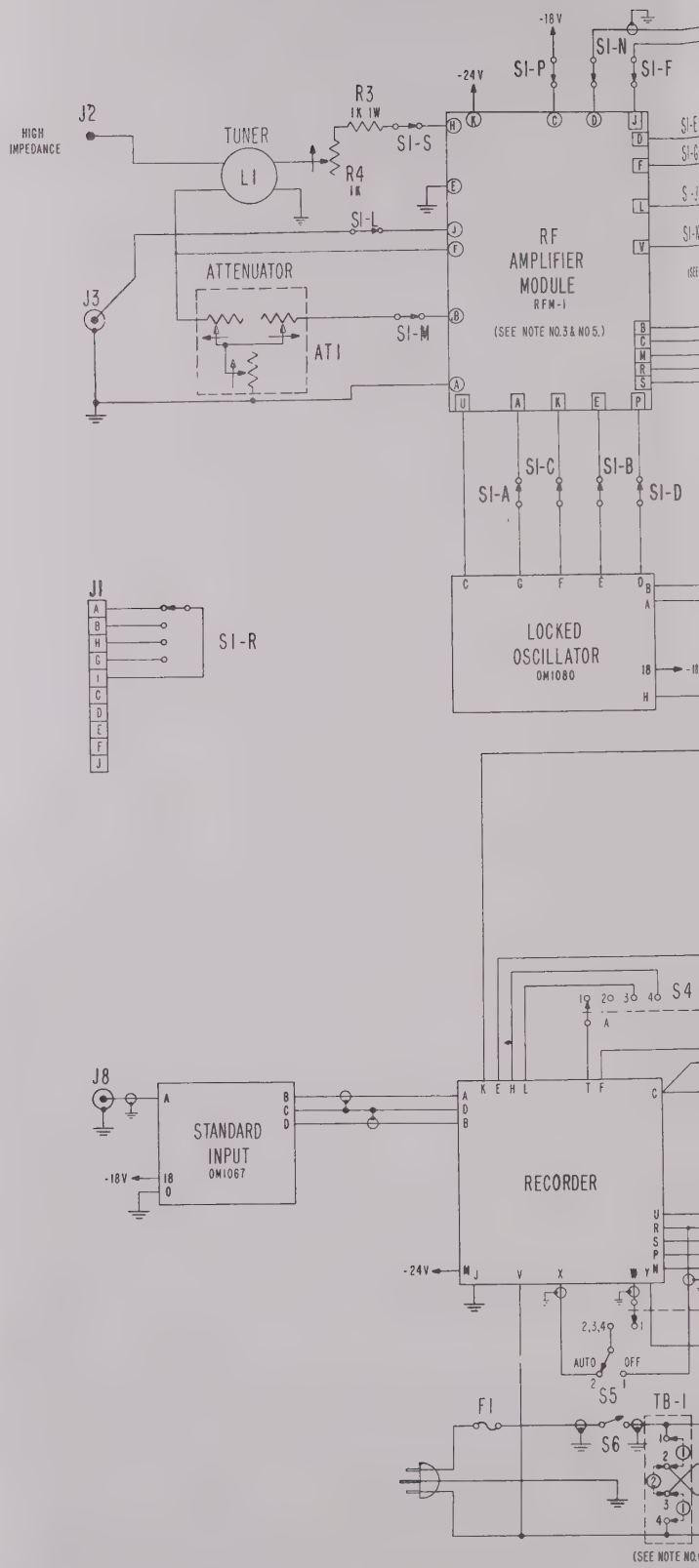
REF SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.	FREQUENCY (KC)										
				14.7	16	18	18.6	19.8	20	22.3	60	77.5		
C2001	Capacitor, polystyrene, 0.005 uf ±2%	Westcap	WR94U1502									1		
J2001	Connector, 9 pin	Winchester	MRE9PG	1	1	1	1	1	1	1	1	1		
J2002	Connector, 18 pin	Winchester	MRE18PG	1	1	1	1	1	1	1	1	1		
R2001	Potentiometer, 10K	Ohmite	CLU1031	1	1	1	1	1	1	1	1	1		
	INPUT AMPLIFIER	Gertsch	AA989											
C2101	Capacitor, polystyrene, 0.01 uf	Westcap	WR94U1103	1	1	1	1	1	1	1				
	Capacitor, polystyrene, 0.001 uf	Westcap	WR94U1102								1	1		
C2102	Capacitor, paper, 0.1 uf, 50V	Westcap	WS4104	1	1	1	1	1	1	1	1	1		
C2103	Capacitor, electrolytic, 40 uf, 6V	Sprague	TE1095	1	1	1	1	1	1	1	1	1		
L2101	Coil	Gertsch	LA16 (FREQ)	1	1	1	1	1	1	1	1	1		
Q2101	Transistor		2N2374	1	1	1	1	1	1	1				
	Transistor		2N1790								1	1		
R2101	Resistor, composition, 100K ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
R2102	Resistor, composition, 27K ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
R2103	Resistor, composition, 27K ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
R2104	Resistor, composition, 1K ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
R2105	Resistor, composition, 8.2K ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
	AGC AMPLIFIER	Gertsch	AA991											
C2201	Capacitor, tantalum, 3.3 uf, 6V	Texas Instrument	SCM335FP06A4	1	1	1	1	1	1	1	1	1		
C2202	Capacitor, electrolytic, 40 uf, 6V	Sprague	TE1095	1	1	1	1	1	1	1	1	1		
C2203	Capacitor, electrolytic, 10 uf, 25V	Sprague	TE1204	1	1	1	1	1	1	1	1	1		
CR2201	Diode		1N457	1	1	1	1	1	1	1	1	1		
CR2202	Diode		1N457	1	1	1	1	1	1	1	1	1		
Q2201	Transistor		2N2374	1	1	1	1	1	1	1				
	Transistor		2N1790								1	1		
R2201	Resistor, composition, 10K ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
R2202	Resistor, composition, 4.7K ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
R2203	Resistor, composition, 4.7K ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
R2204	Resistor, composition, 27K ±10%, 1/4W			1	1	1	1	1	1	1	1	1		

REF SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.	FREQUENCY (KC)										
				14.7	16	18	18.6	19.8	20	22.3	60	77.5		
	FIRST AND THIRD OUTPUT AMPLIFIER	Gertsch	AA992											
C2301, C2501	Capacitor, paper, 0.1 uf, 50V	Westcap	WS4104	1	1	1	1	1	1	1	1	1		
C2302, C2502	Capacitor, polystyrene, 0.01 uf	Westcap	WR94U1103	1	1	1	1	1	1	1				
	Capacitor, polystyrene, 0.001 uf	Westcap	WR94U1102								1	1		
C2303, C2503	Capacitor, electrolytic, 40 uf, 6V	Sprague	TE1095	1	1	1	1	1	1	1	1	1		
C2304, C2504	Capacitor, electrolytic, 10 uf, 25V	Sprague	TE1204	1	1	1	1	1	1	1	1	1		
L2301, L2501	Coil	Gertsch	LA17 (FREQ)	1	1	1	1	1	1	1	1	1		
Q2301, Q2501	Transistor		2N2374	1	1	1	1	1	1	1				
	Transistor		2N1790								1	1		
R2301, R2501	Resistor, composition, 47K ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
R2302, R2502	Resistor, composition, 22K ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
R2303, R2503	Resistor, composition, 100 ohms ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
R2304, R2504	Resistor, composition, 2.7K ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
R2305, R2505	Resistor, composition, 4.7K ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
	SECOND OUTPUT AMPLIFIER	Gertsch	AA993											
C2401	Capacitor, paper, 0.1 uf, 50V	Westcap	WS1404	1	1	1	1	1	1	1	1	1		
C2402	Capacitor, electrolytic, 40 uf, 6V	Sprague	TE1095	1	1	1	1	1	1	1	1	1		
C2403	Capacitor, electrolytic, 10 uf, 25V	Sprague	TE1204	1	1	1	1	1	1	1	1	1		
Q2401	Transistor		2N2374	1	1	1	1	1	1	1				
	Transistor		2N1790								1	1		
R2401	Resistor, composition, 33K ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
R2402	Resistor, composition, 8.2K ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
R2403	Resistor, composition, 2.7K ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
R2404	Resistor, composition, 100 ohms ±10%, 1/4W			1	1	1	1	1	1	1	1	1		

REF SYMBOL	DESCRIPTION	MANUFACTURER	PART NO.	FREQUENCY (KC)										
				14.7	16	18	18.6	19.8	20	22.3	60	77.5		
R2405	Resistor, composition, 1.2K ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
R2406	Resistor, composition, 4.7K ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
	OSCILLATOR ASSEMBLY	Gertsch	AA994											
C2601	Capacitor, electrolytic, 10 uf, 25V	Sprague	TE1204	1	1	1	1	1	1	1	1	1		
C2602	Capacitor, polystyrene, 1200 pf	Westcap	WR94U1122			1	1	1	1	1	1			
	Capacitor, polystyrene, 1000 pf	Westcap	WR94U1102	1	1							1		
C2603	Capacitor, paper, 0.05 uf	Aerovox	P8292ZN9	1	1	1	1	1	1	1	1	1		
CR2601	Diode		1N457	1	1	1	1	1	1	1	1	1		
CR2602	Diode, Zener	Transitron	SC15	1	1	1	1	1	1	1	1	1		
L2601	Coil	Gertsch	LA19 (FREQ)	1	1	1	1	1	1	1	1	1		
R2601	Resistor, composition, 680 ohms ±10%, 1/4W			1	1	1	1	1	1	1	1	1		
R2602	Resistor, composition, 10K nominal value			1	1	1	1	1	1	1	1	1		
R2603	Resistor, composition, 470 ohms ±10%, 1/4W			1	1	1	1	1	1	1	1	1		

SECTION III

SCHEMATIC DIAGRAMS


HIGH IMPEDANCE
J2
TUNER
L1
R3
1K 1W
R4
1K
SI-S
SI-L
ATTENUATOR
AT1
J3
SI-M
RF AMPLIFIER MODULE
RFM-1
(SEE NOTE NO.3 & NO 5.)
-18 V
-24 V
SI-P
SI-N
SI-F
SI-A
SI-C
SI-B
SI-D
J1
SI-R
LOCKED OSCILLATOR
OM1080
J8
STANDARD INPUT
OM1067
-18V
RECORDER
-24V
S4
S5
S6
F1
TB-1
AUTO
OFF
2,3,4
(SEE NOTE NO.

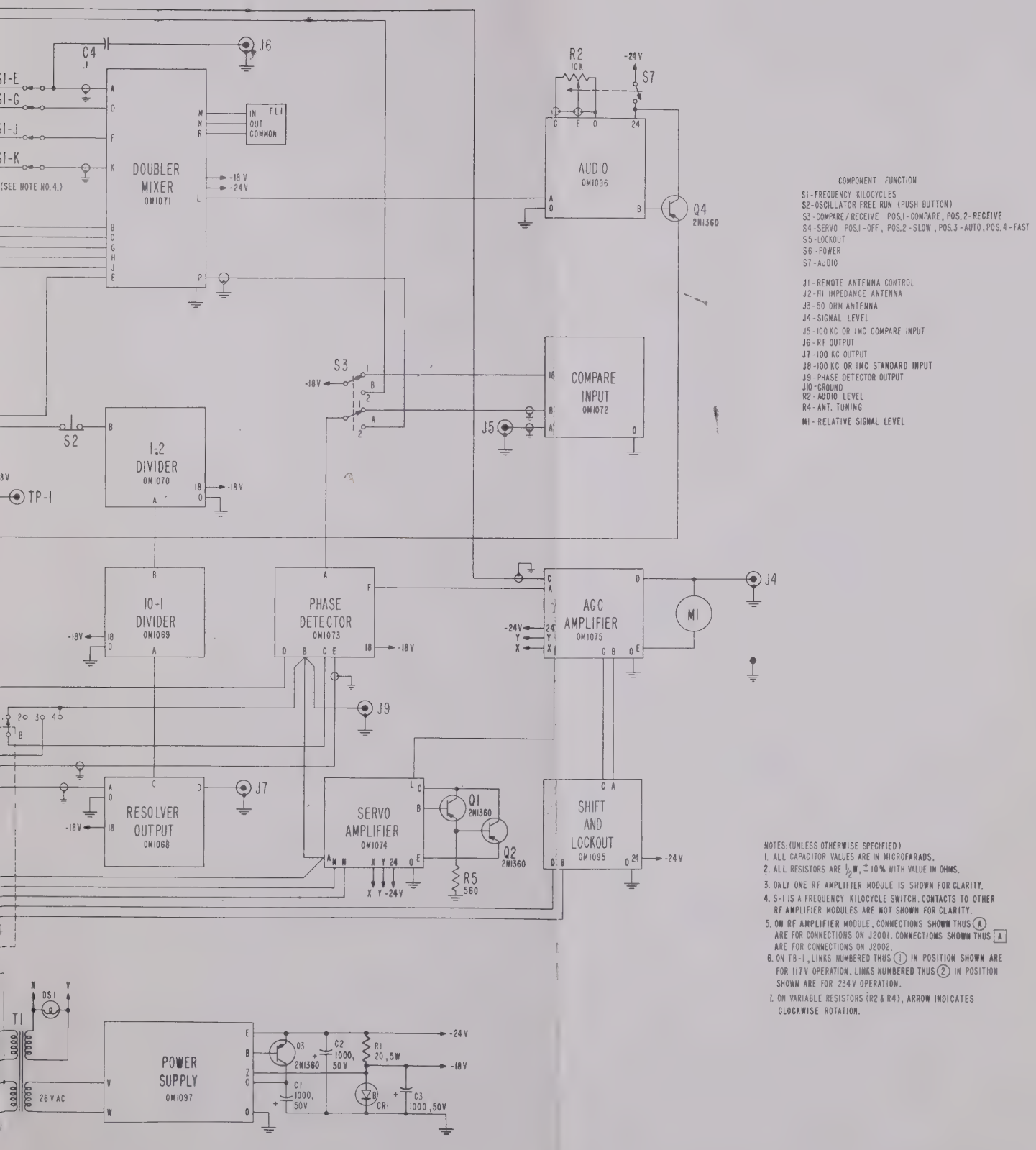


Figure 8-1. Chassis Interconnection and Schematic Diagram

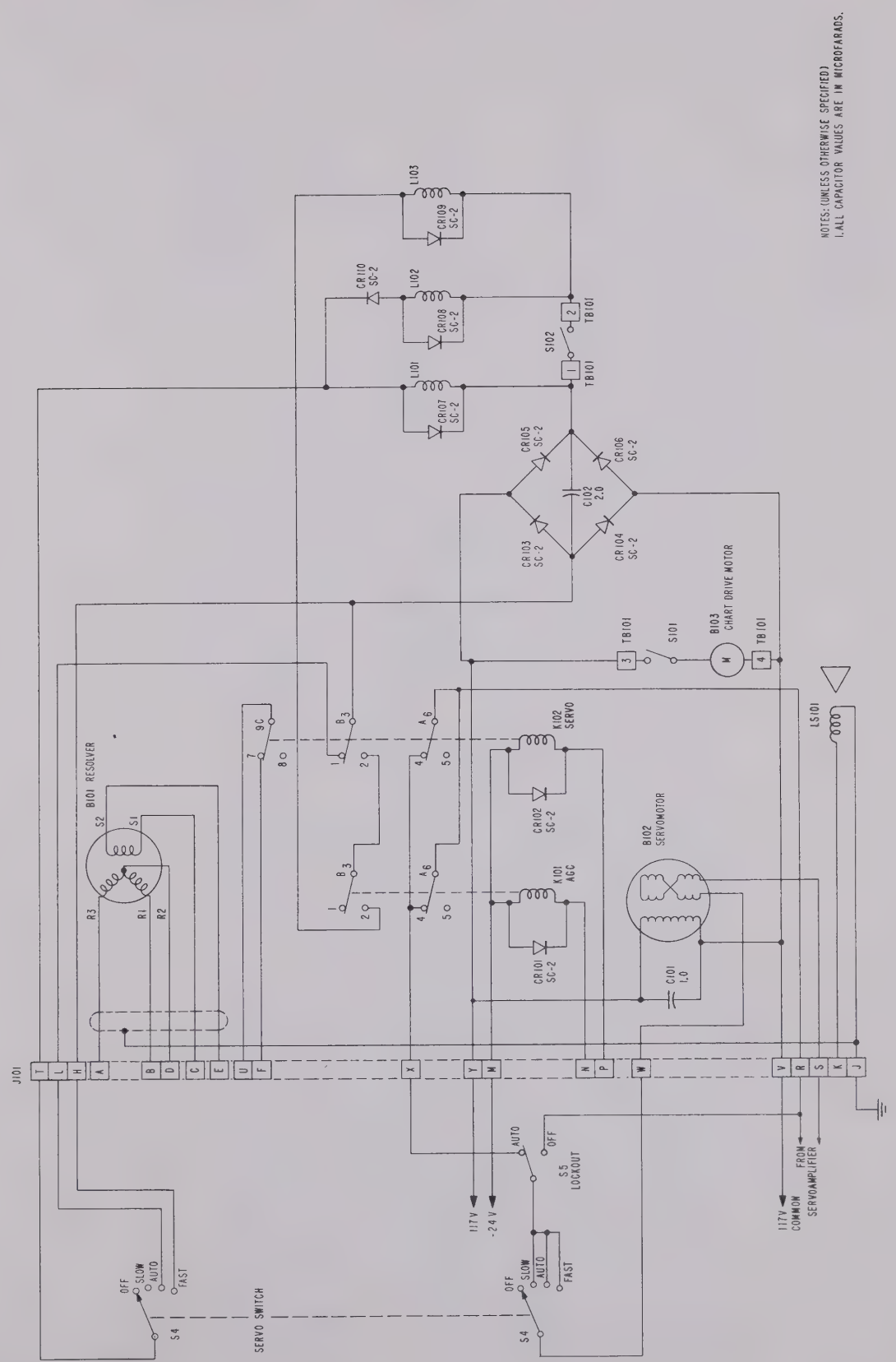


Figure 8-2. Recorder - Servo Assembly

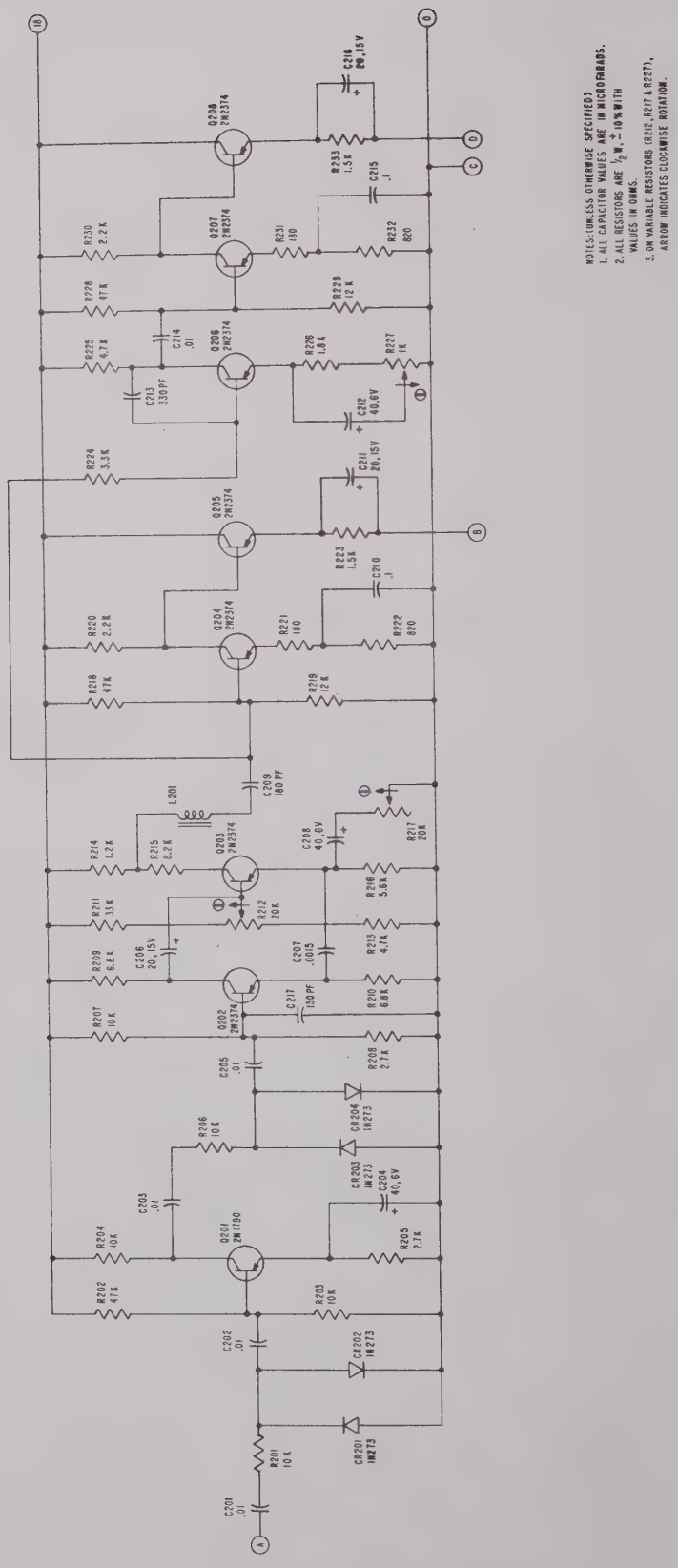


Figure 8-3. Standard Input Assembly

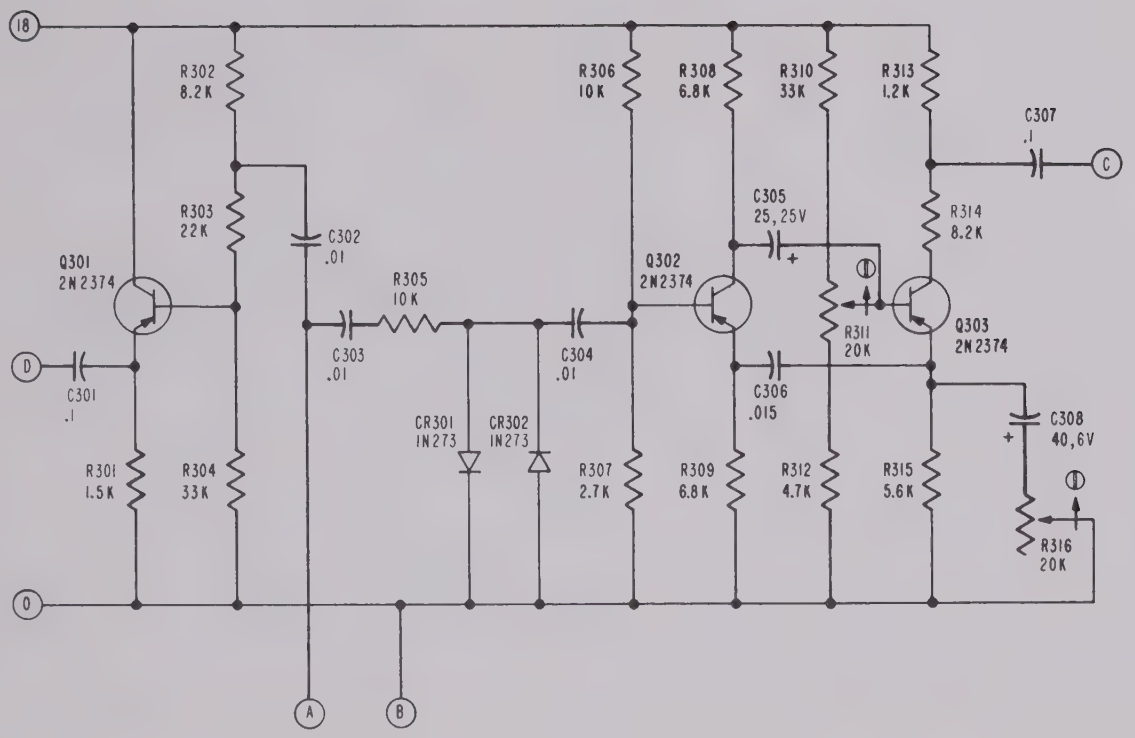


Figure 8-4. Resolver Output Assembly

NOTES: (UNLESS OTHERWISE SPECIFIED)
1. ALL CAPACITOR VALUES ARE IN MICROFARADS.
2. ALL RESISTORS ARE $\frac{1}{2}$ W, $\pm$ 10% WITH VALUES IN OHMS.
3. ON VARIABLE RESISTORS (R311 & R316), ARROW INDICATES CLOCKWISE ROTATION.

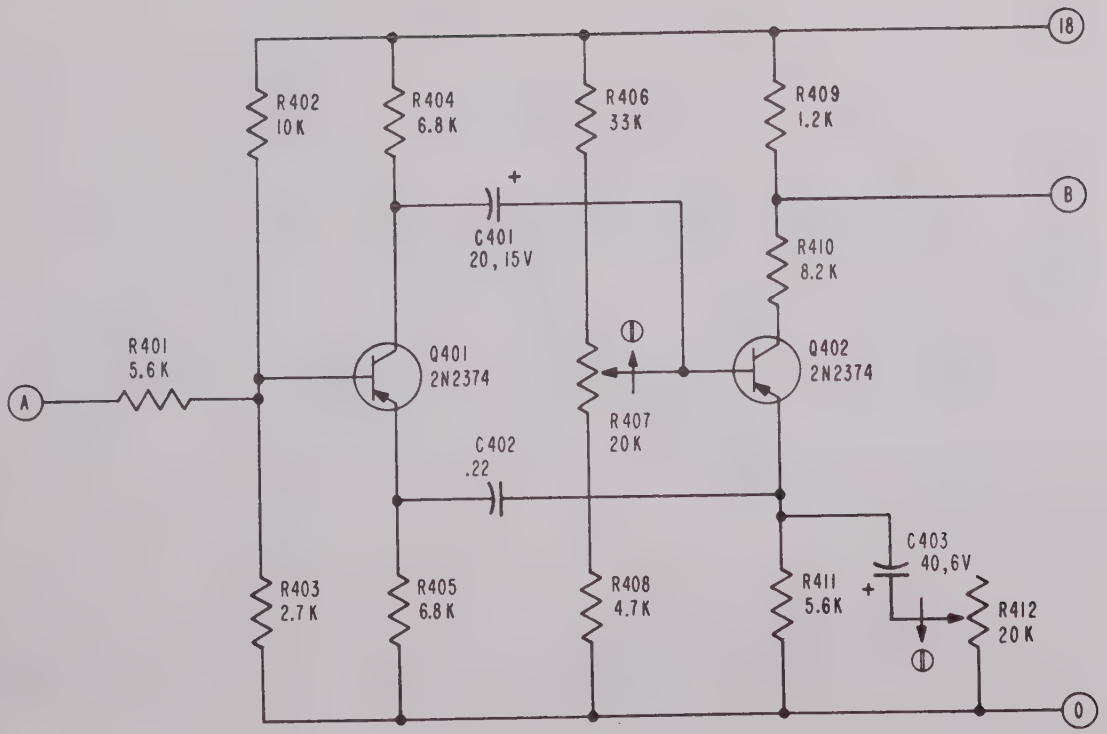


Figure 8-5. 10 KC to 1 KC Divider Assembly

NOTES: (UNLESS OTHERWISE SPECIFIED)
1. ALL CAPACITOR VALUES ARE IN MICROFARADS.
2. ALL RESISTORS ARE $\frac{1}{2}$ W, $\pm$ 10% WITH VALUES IN OHMS.
3. ON VARIABLE RESISTORS (R407 & R412), ARROW INDICATES CLOCKWISE ROTATION.

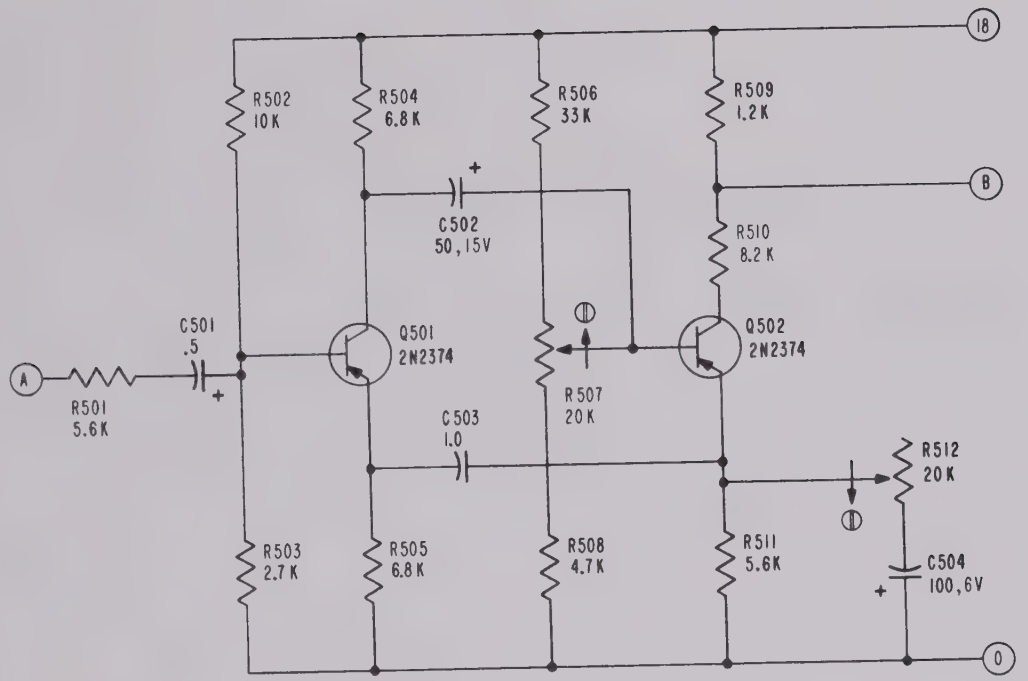


Figure 8-6. 1 KC to .2 KC Divider Assembly

NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL CAPACITOR VALUES ARE IN MICROFARADS.
2. ALL RESISTORS ARE $\frac{1}{2}$ W, $\pm$10% WITH VALUES IN OHMS.
3. ON VARIABLE RESISTORS (R507 & R512), ARROW INDICATES CLOCKWISE ROTATION.

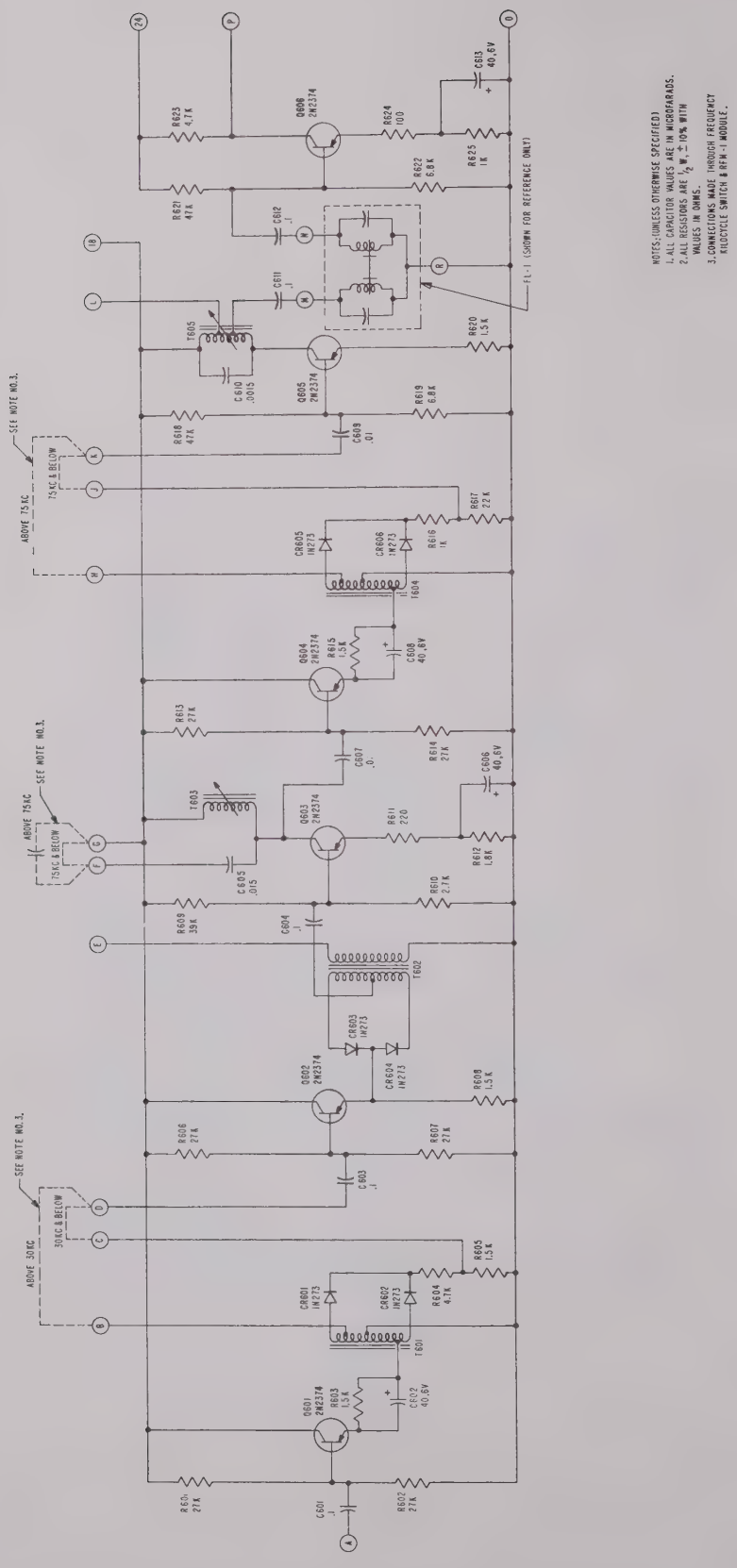
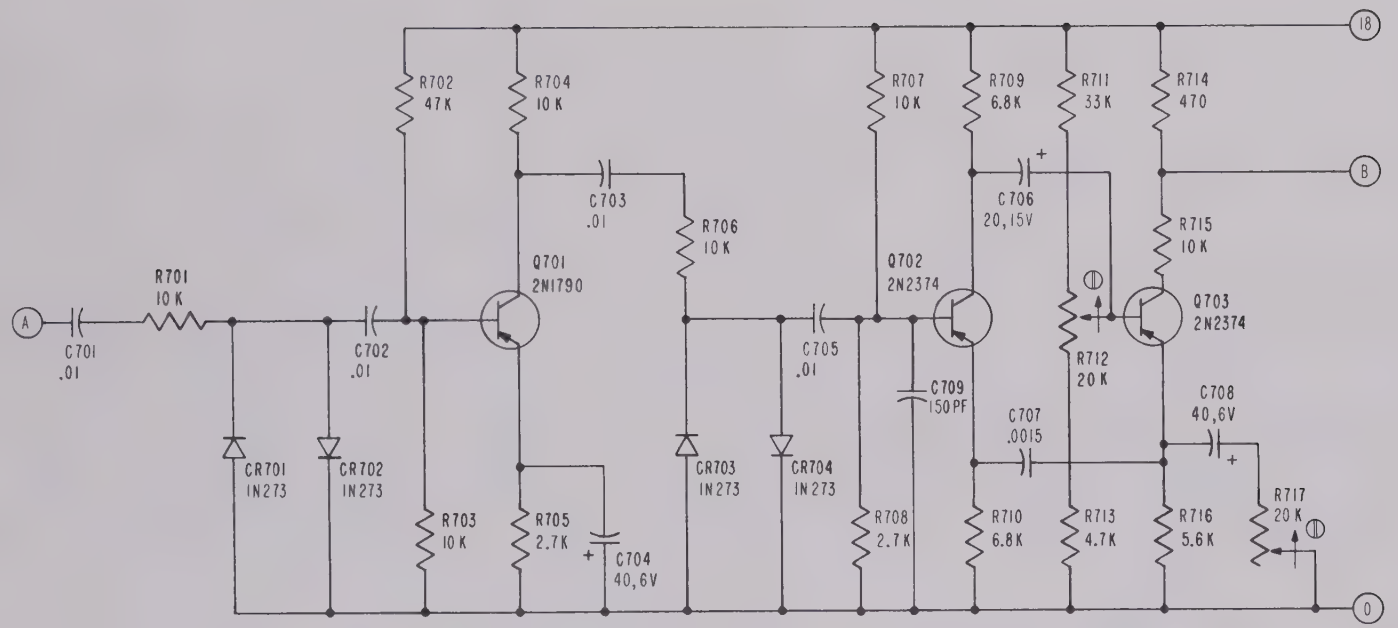

NOTES: (UNLESS OTHERWISE SPECIFIED)
1. ALL CAPACITOR VALUES ARE IN MICROFARADS.
2. ALL RESISTORS ARE 1/2 W. ± 10% WITH VALUES IN OHMS.
3. CONNECTIONS MADE THROUGH FREQUENCY KILOCYCLE SWITCH & RFM-1 MODULE.
FL-1 (SHOWN FOR REFERENCE ONLY)
SEE NOTE NO.3.
ABOVE 75 MC
75 MC & BELOW
ABOVE 30 MC
30 MC & BELOW

Figure 8-7. Doubler-Mixer Assembly



NOTES: (UNLESS OTHERWISE SPECIFIED)
1. ALL CAPACITOR VALUES ARE IN MICROFARADS.
2. ALL RESISTORS ARE $\frac{1}{2}$ W, $\pm$ 10% WITH VALUES IN OHMS.
3. ON VARIABLE RESISTORS (R712 & R717), ARROW INDICATES CLOCKWISE ROTATION.

Figure 8-8. Compare Input Assembly

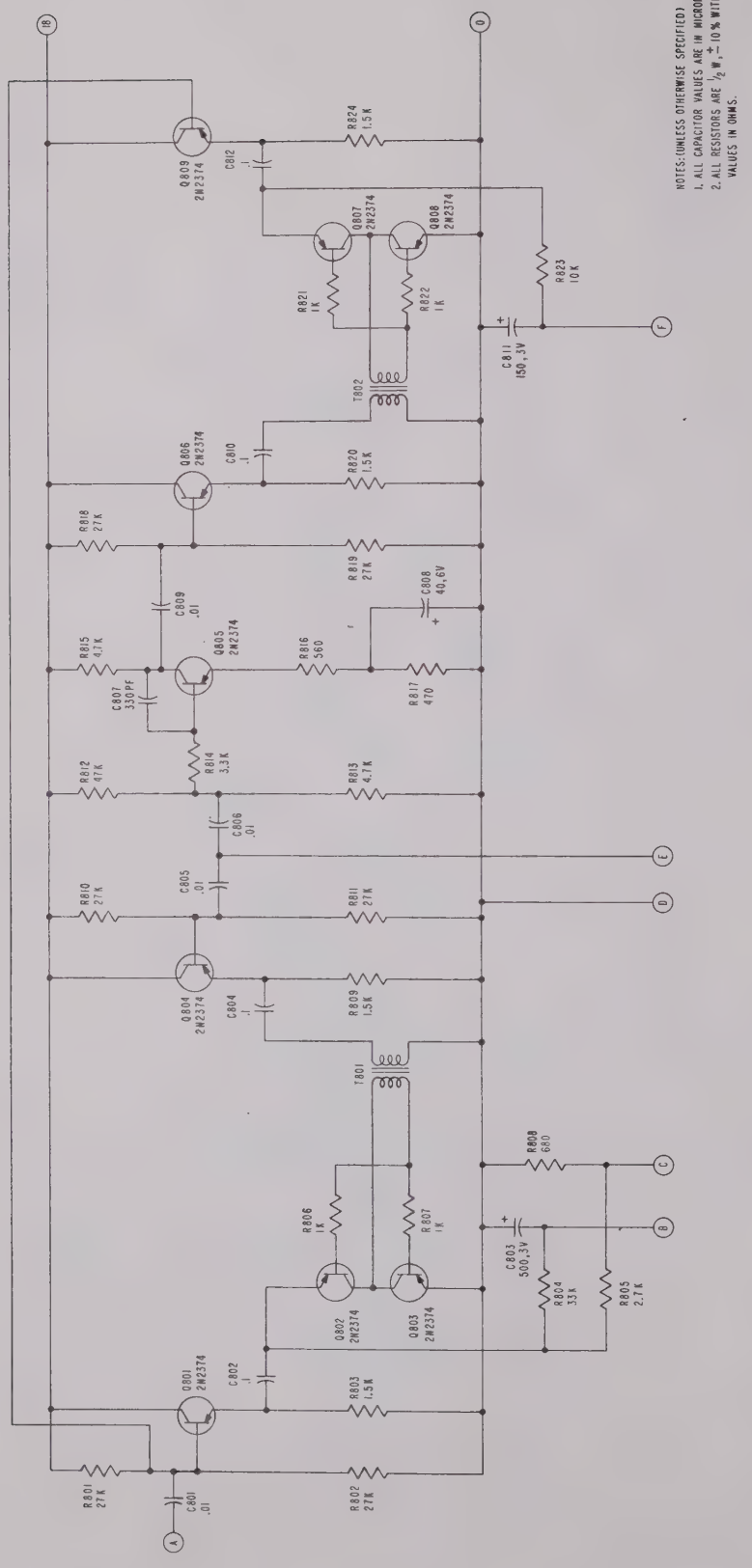
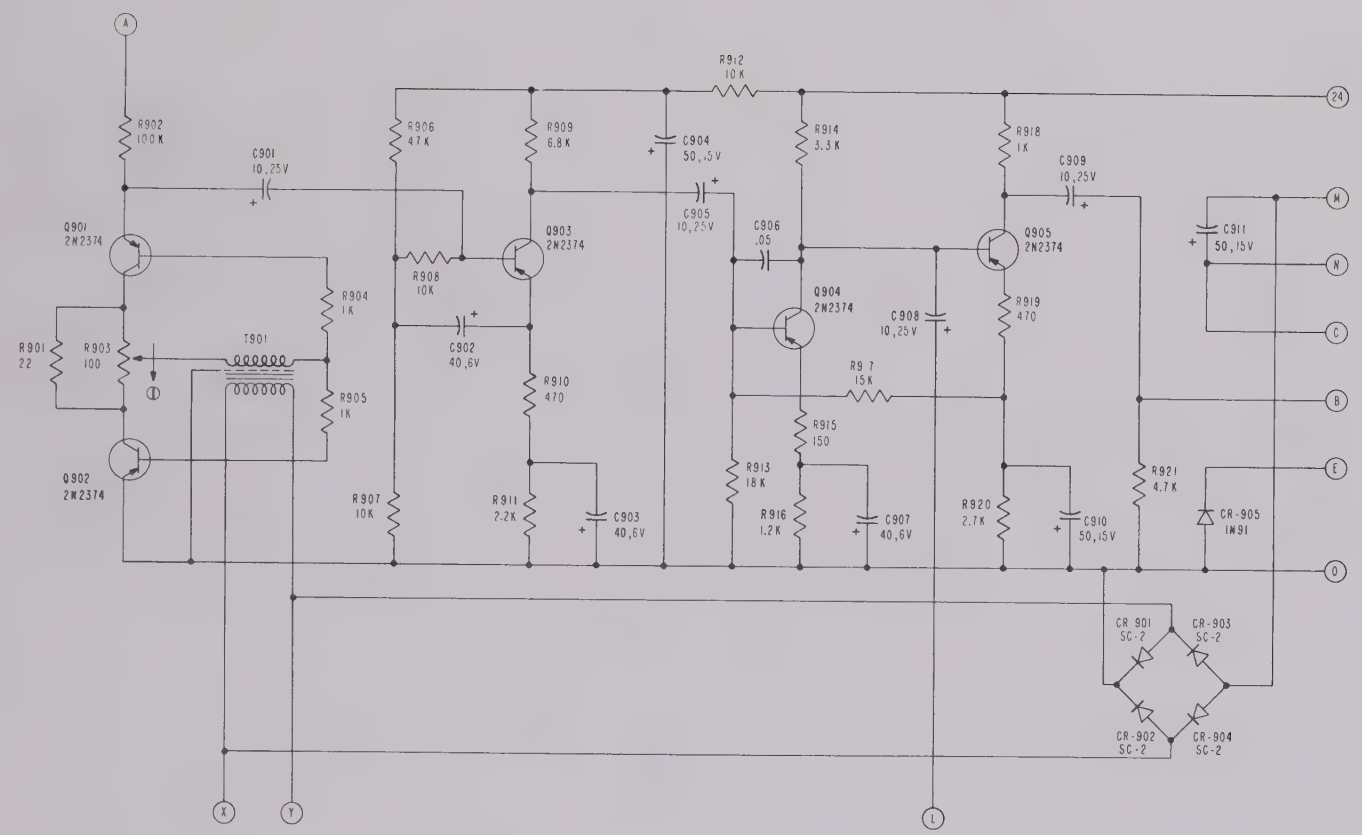


Figure 8-9. Phase Detector Assembly



NOTES: (UNLESS OTHERWISE SPECIFIED)
1. ALL CAPACITOR VALUES ARE IN MICROFARADS.
2. ALL RESISTORS ARE $\frac{1}{2}$ W, $\pm$ 10% WITH VALUES IN OHMS.
3. ON VARIABLE RESISTOR (R903), ARROW INDICATES CLOCKWISE ROTATION.

Figure 8-10. Servo Amplifier Assembly

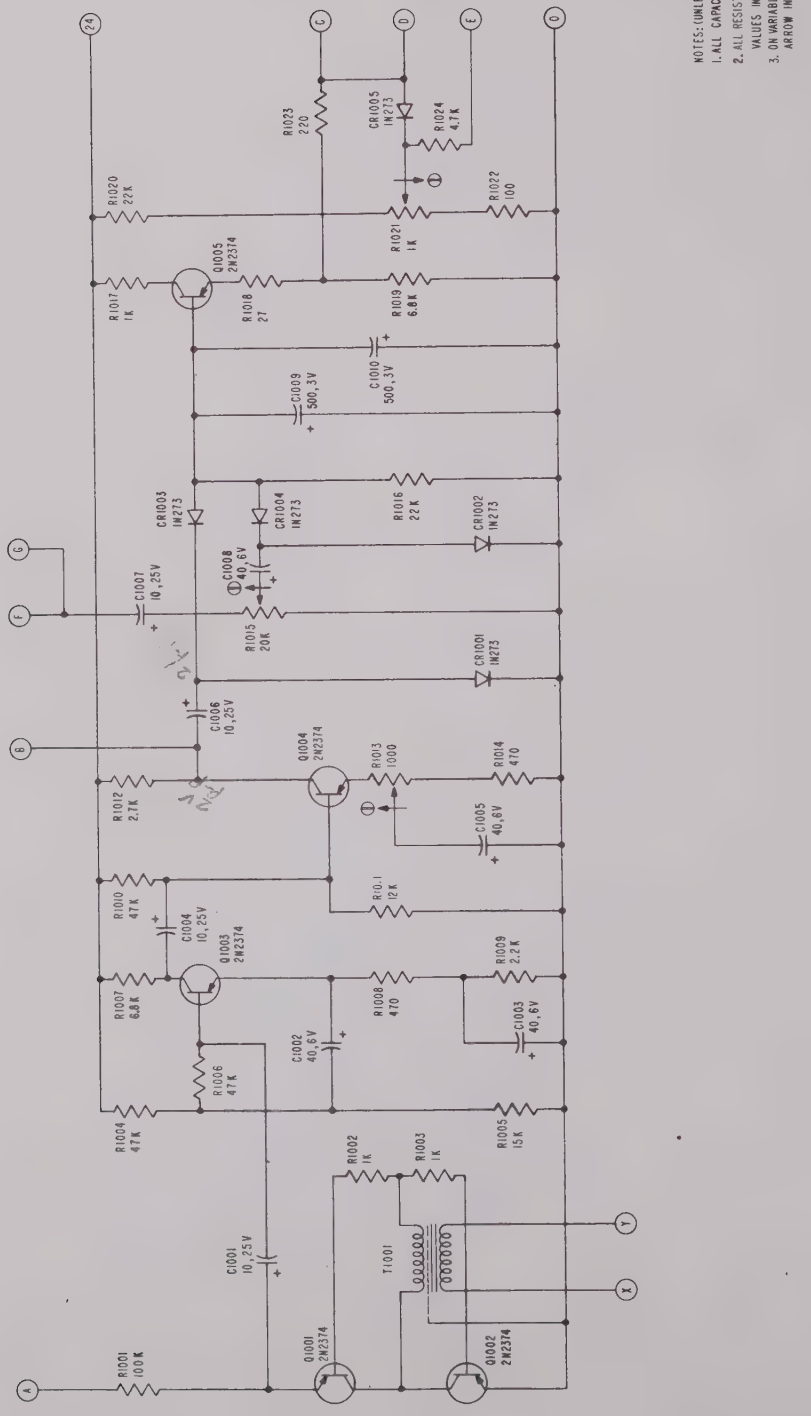
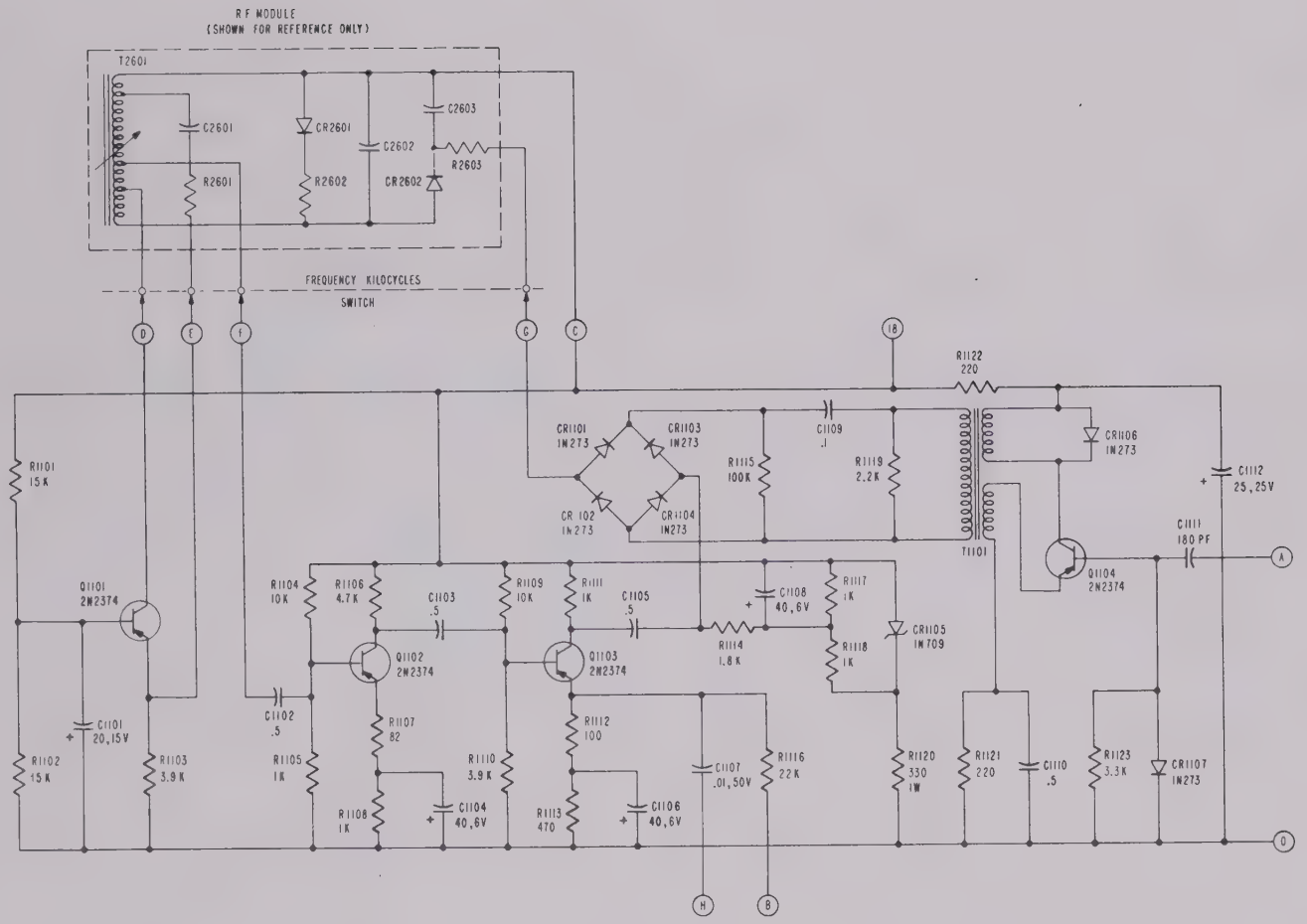
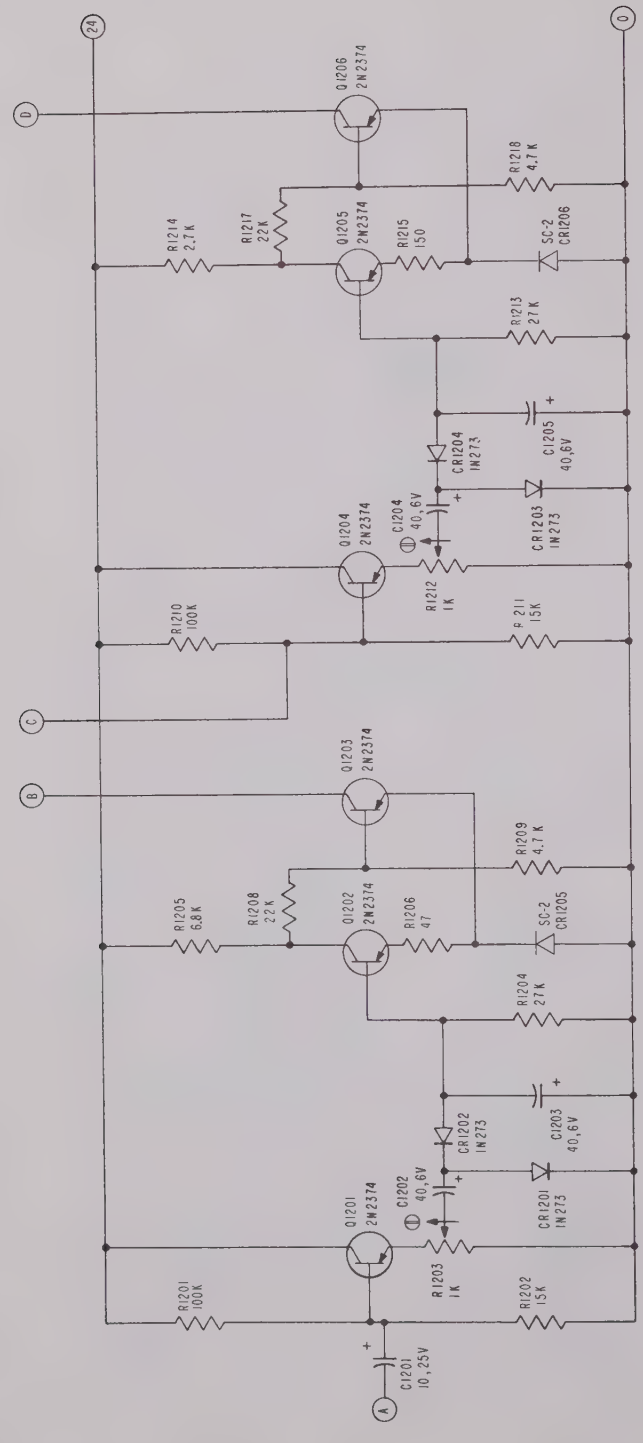


Figure 8-11. AGC Amplifier Assembly



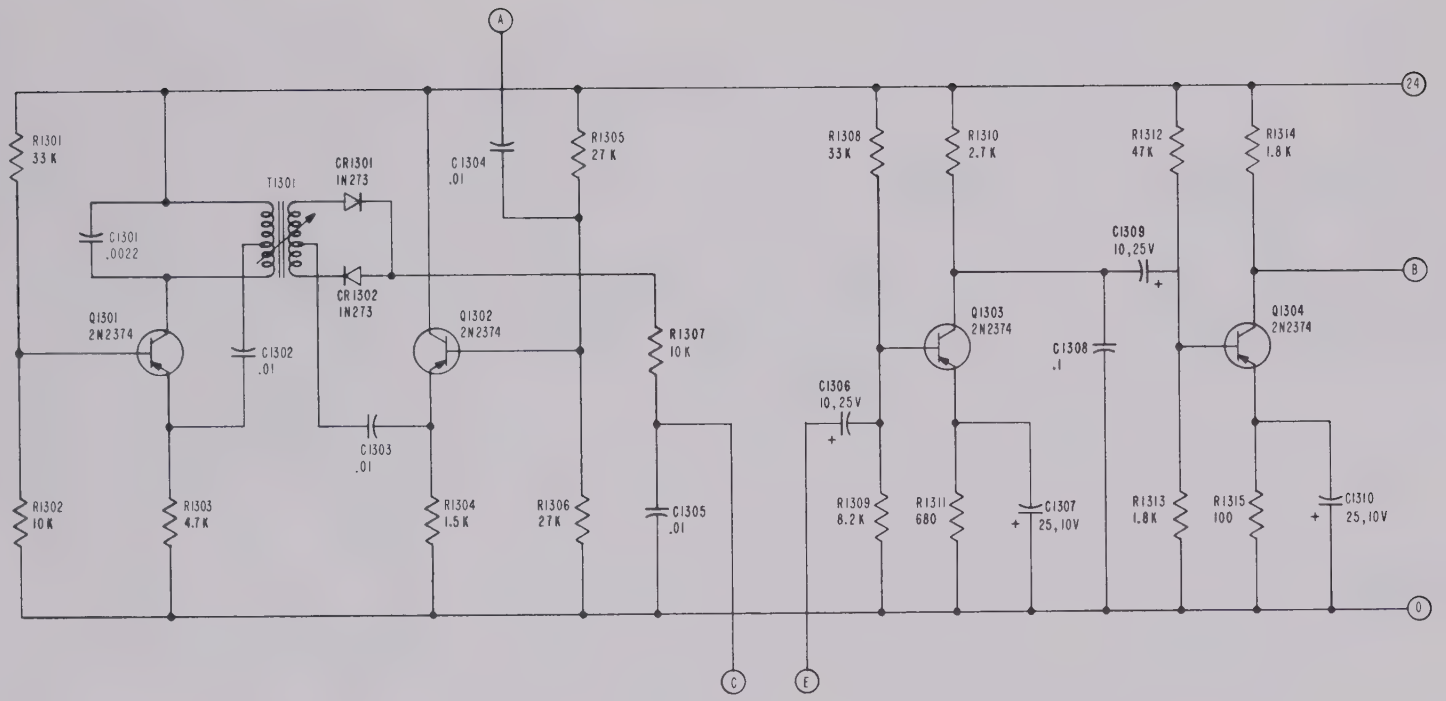
NOTES: (UNLESS OTHERWISE SPECIFIED)
1. ALL CAPACITOR VALUES ARE IN MICROFARADS.
2. ALL RESISTORS ARE $\frac{1}{2}$ W, $\pm$ 10% WITH VALUES IN OHMS.

Figure 8-12. Phase Locked Oscillator Assembly



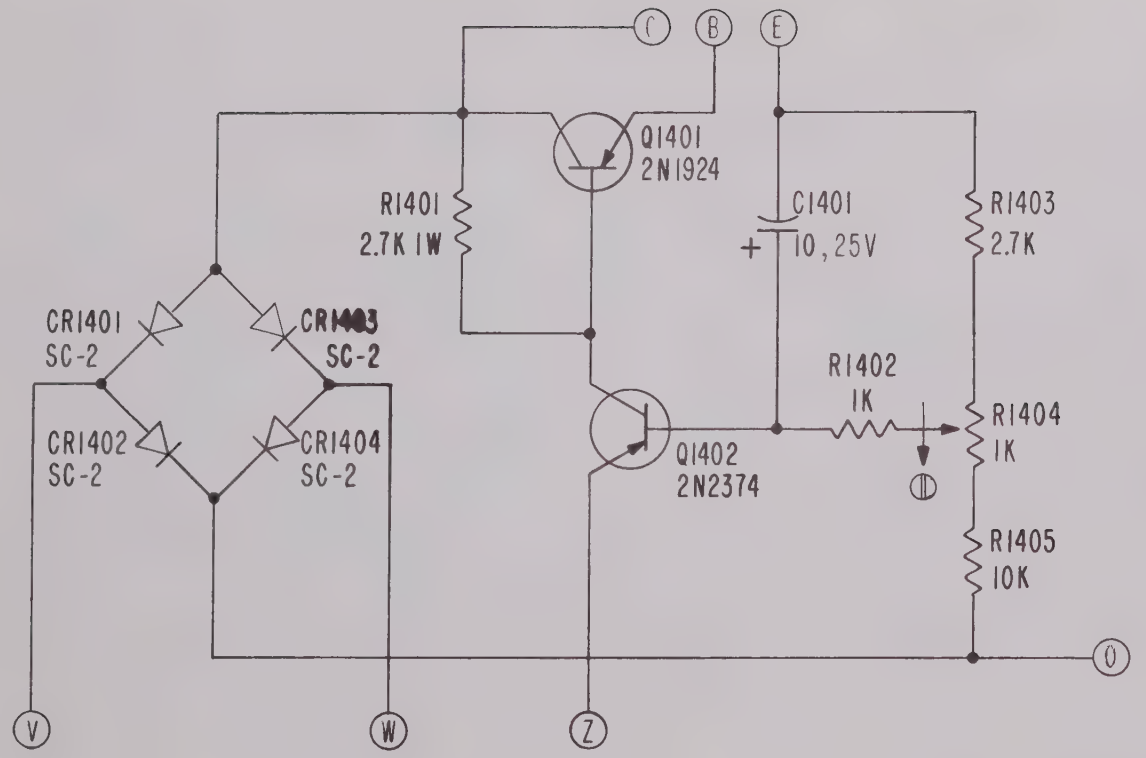
NOTES: (UNLESS OTHERWISE SPECIFIED)
1. ALL CAPACITOR VALUES ARE IN MICROFARADS.
2. ALL RESISTORS ARE $\frac{1}{2}$ W, $\pm$10% WITH VALUES IN OHMS.
3. ON VARIABLE RESISTORS (R1203 & R1212), ARROW INDICATES CLOCKWISE ROTATION.

Figure 8-13. Shift and Lockout Assembly



NOTES: (UNLESS OTHERWISE SPECIFIED)
1. ALL CAPACITOR VALUES ARE IN MICROFARADS.
2. ALL RESISTORS ARE $\frac{1}{2}$W, $\pm$ 10% WITH VALUES IN OHMS.

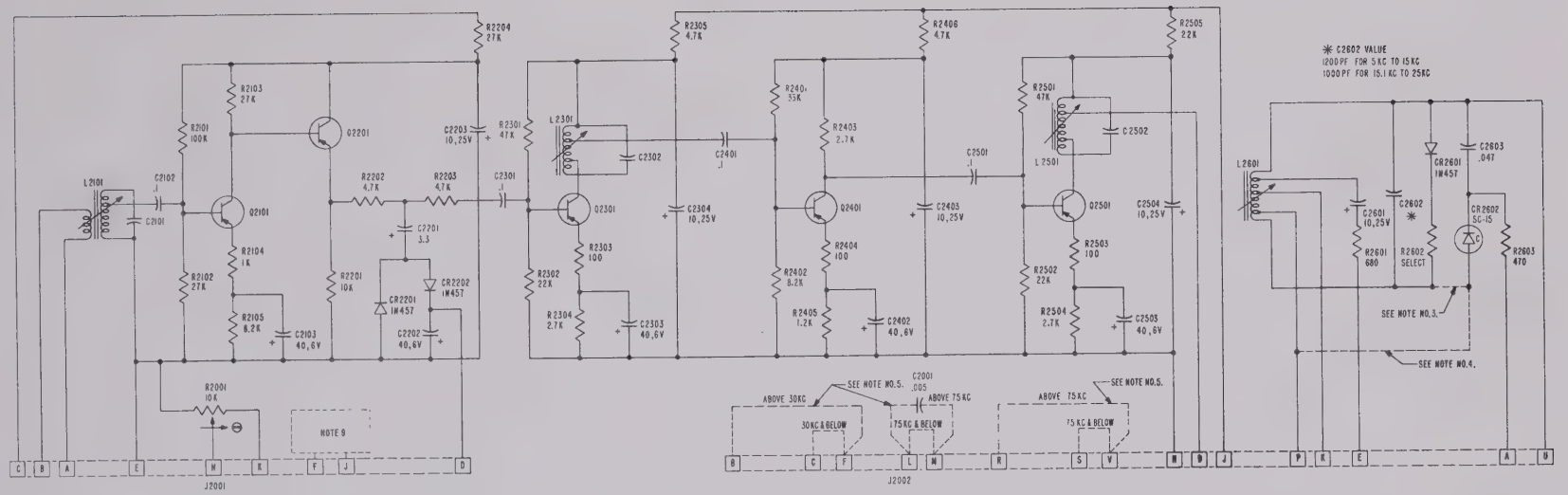
Figure 8-14. Audio Assembly



NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL CAPACITOR VALUES ARE IN MICROFARADS.
2. ALL RESISTORS ARE $\frac{1}{2}$ W, $\pm$ 10% WITH VALUES IN OHMS.
3. ON VARIABLE RESISTOR (R1404), ARROW INDICATES CLOCKWISE ROTATION.

Figure 8-15. Power Supply Assembly

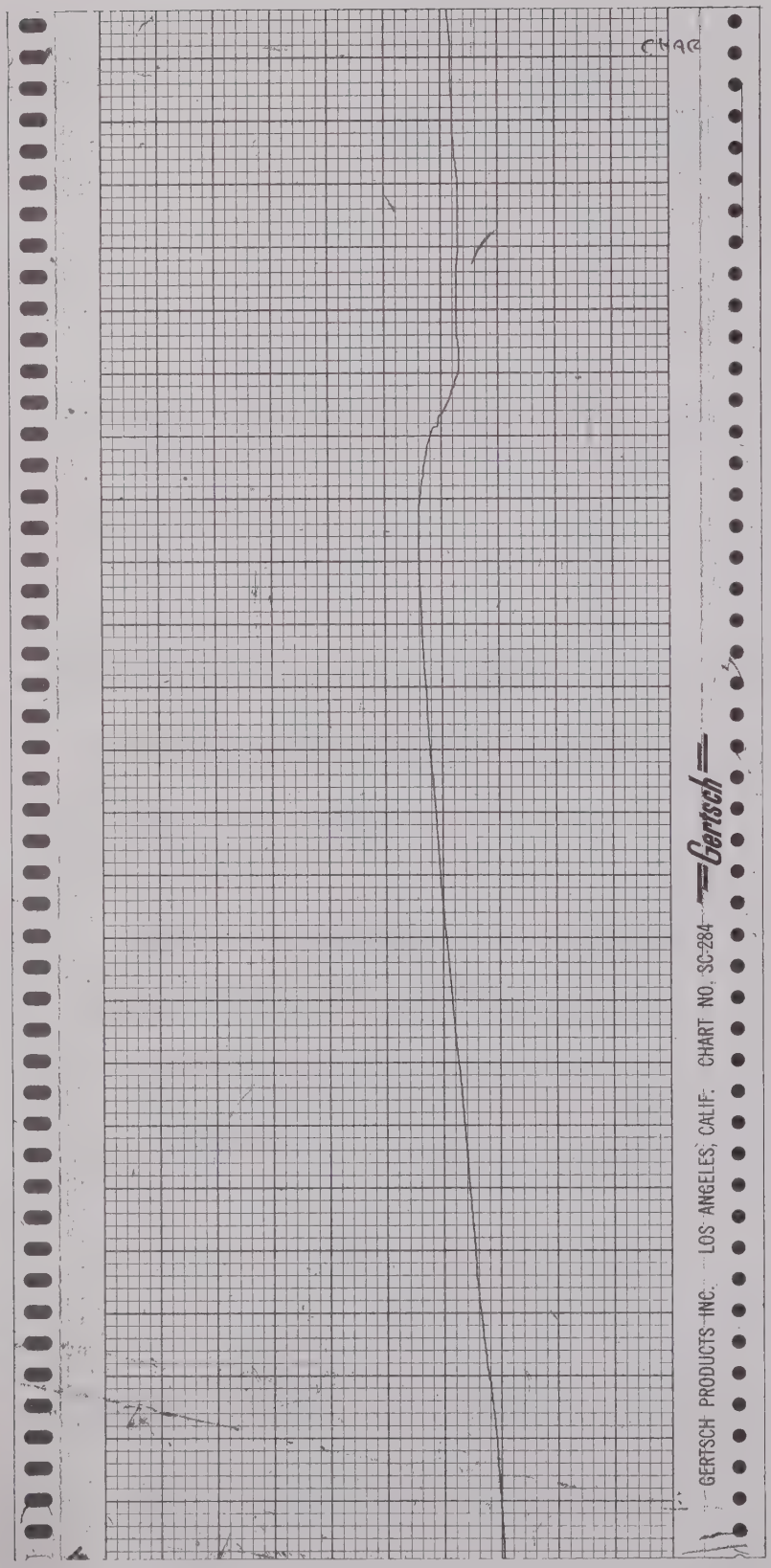


NOTES: (UNLESS OTHERWISE SPECIFIED)
1. ALL CAPACITOR VALUES ARE IN MICROFARADS.
2. ALL RESISTORS ARE 1/4 W, ±10% WITH VALUES IN OHMS.
3. CONNECTIONS USED BELOW 7 KC.
4. CONNECTIONS USED AT 7.1 KC & ABOVE.
5. CONNECTIONS MADE THROUGH FREQUENCY KILOCYCLE SWITCH.
6. VALUES OF C2101, C2302 & C2502 TO BE DETERMINED BY CHANNEL FREQUENCY.
7. ON VARIABLE RESISTOR (R2001), ARROW INDICATES CLOCKWISE ROTATION.
8. BELOW 30.1 KC ALL TRANSISTORS ARE 2N2374. ABOVE 30.0 KC ALL TRANSISTORS ARE 2N1790.
9. TUNING NETWORK FOR SPECIAL LOOP ANTENNA APPLICATIONS. (OPTIONAL) JUMPER BETWEEN F & J IF NOT SPECIFIED.

Figure 8-16. RFM-1 Module

SECTION IX

REPRESENTATIVE CHART RECORDINGS



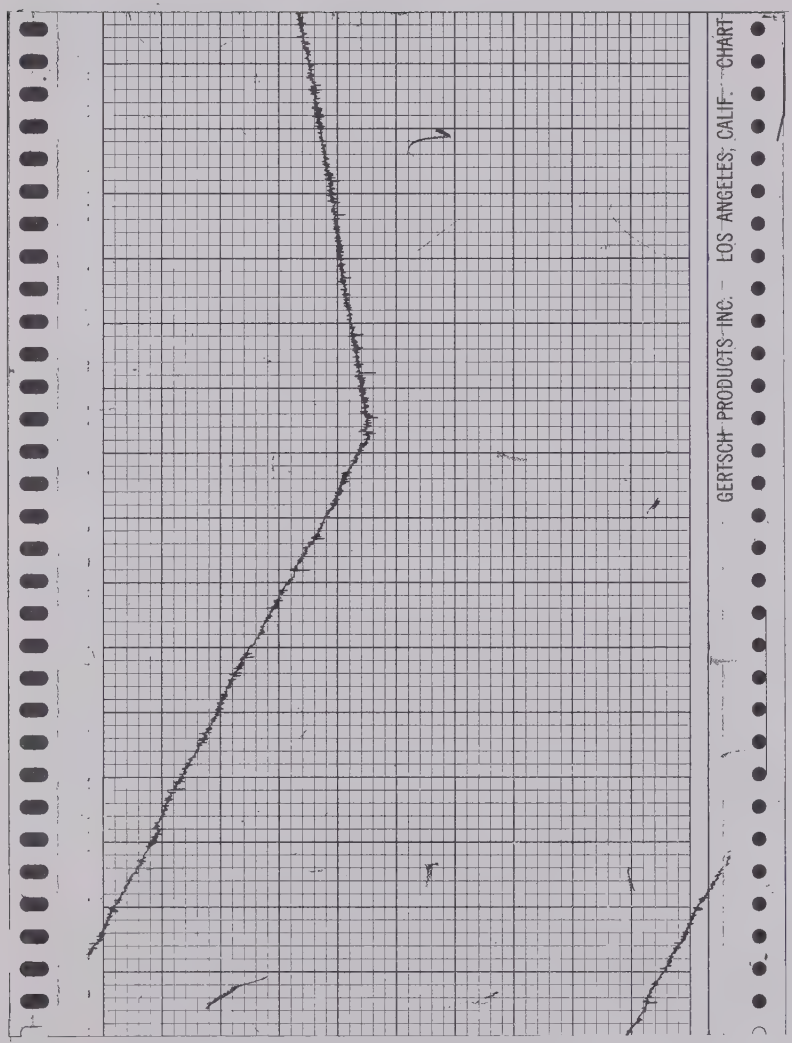
SYSTEM MODE - Receive
SERVO MODE - Auto
SERVO LOCKOUT SWITCH - Auto
VLF FREQUENCY - 60 KC
CHART SPEED - 1 inch per hour

NOTES:

A superior recording obtained with a good, steady signal and an accurate, stable standard.

The recording shows a small, consistent error except for the diurnal shift period.

Figure 9-1. Superior Recording



SYSTEM MODE - Receive

SERVO MODE - Fast

SERVO LOCKOUT SWITCH - Auto

VLF FREQUENCY - 60 KC

CHART SPEED - 4 inches per hour

NOTES:

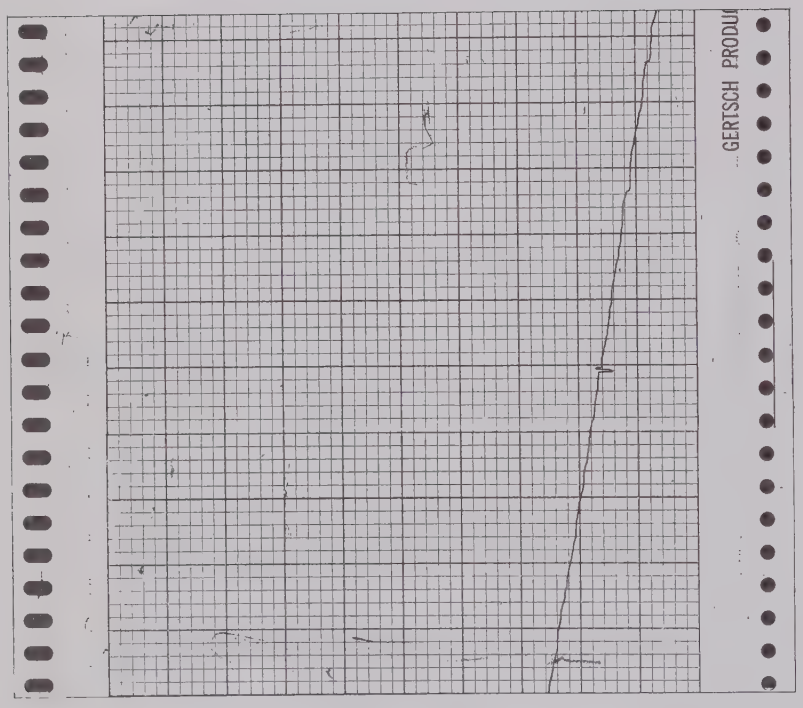
The change in error indication from high to low is a result of adjusting the frequency of the local standard.

The Fast speed marker is present on the right margin of the chart.

The dots on the left margin of the chart indicate short periods of marginal reception.

Before adjustment the local standard was approximately 1.5×10^{-8} high in frequency; after, it was 4×10^{-9} low.

Figure 9-2. Recording of Standard Adjustment



SYSTEM MODE - Receive

SERVO MOTOR - Fast

SERVO LOCKOUT SWITCH - Auto

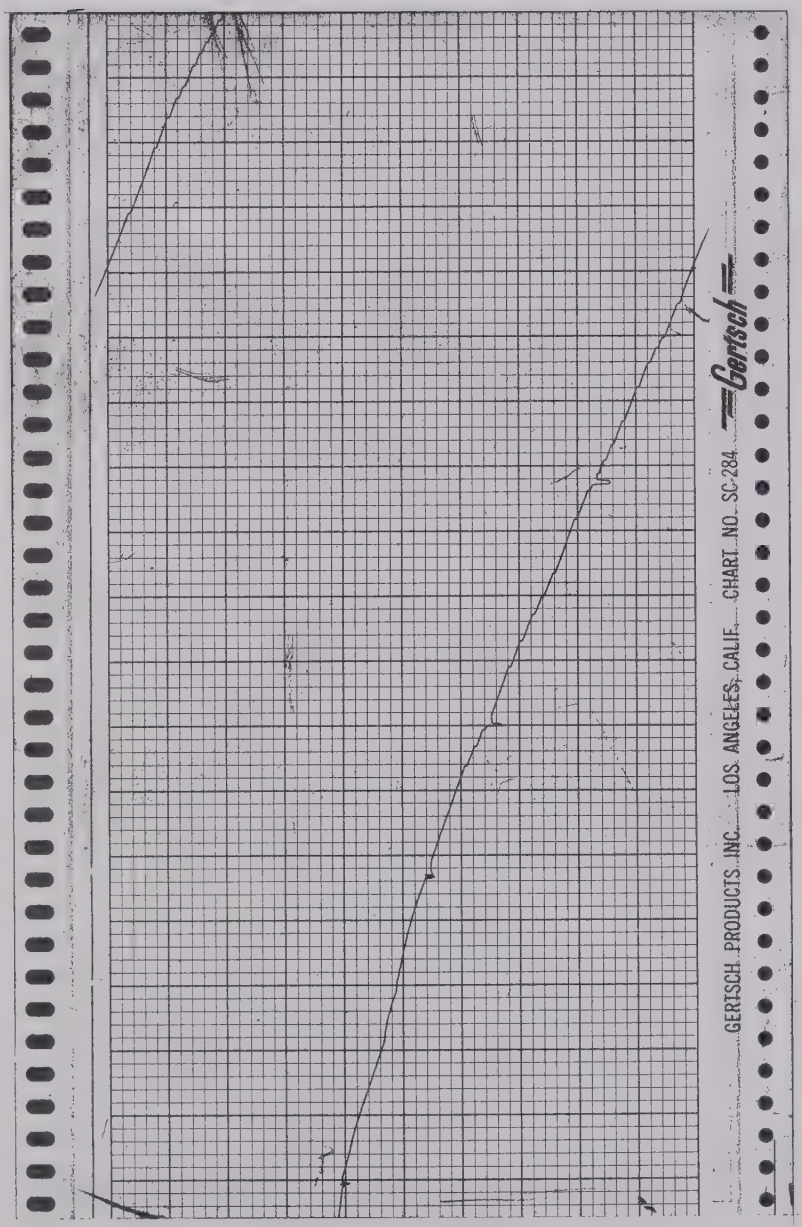
VLF FREQUENCY - 18.0 KC

CHART SPEED - 4 inches per hour

NOTES:

The low duty cycle allows the system to drift between transmissions and then return. In some cases, the recording reflects overcompensation.

Figure 9-3. VLF Signal With Low Duty Cycle

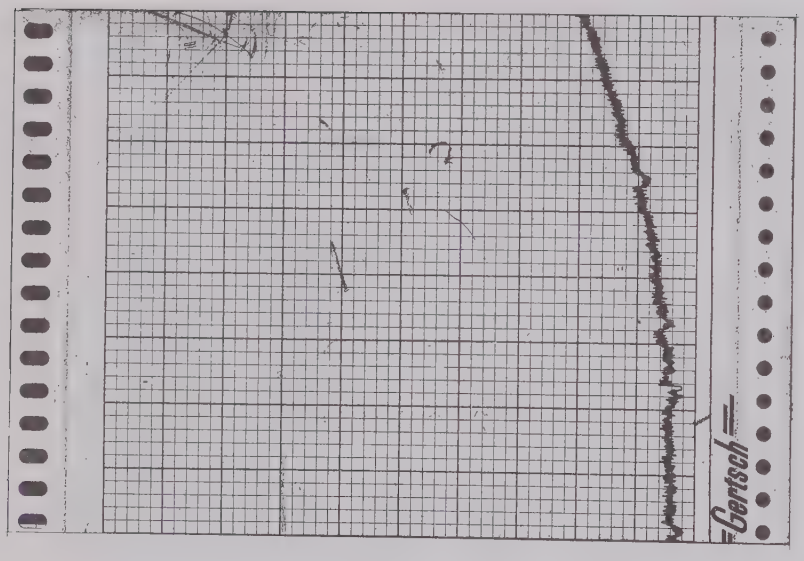


SYSTEM MODE - Receive
SERVO MODE - Auto
SERVO LOCKOUT SWITCH - Auto
VLF FREQUENCY - 20 KC
CHART SPEED - 4 inches per hour

NOTES:

During this period, the 20 KC signal was on for one second and off for one second. The AGC drop-out marker appeared once each second and apparently gave a continuous indication of insufficient signal. A careful study of the indication reveals the dotted pattern and with the consistent error indication the recording becomes a useful, reliable companion.

Figure 9-4. Intermittent Signal



SYSTEM MODE - Receive

SERVO MODE - Auto

SERVO LOCKOUT SWITCH - Auto

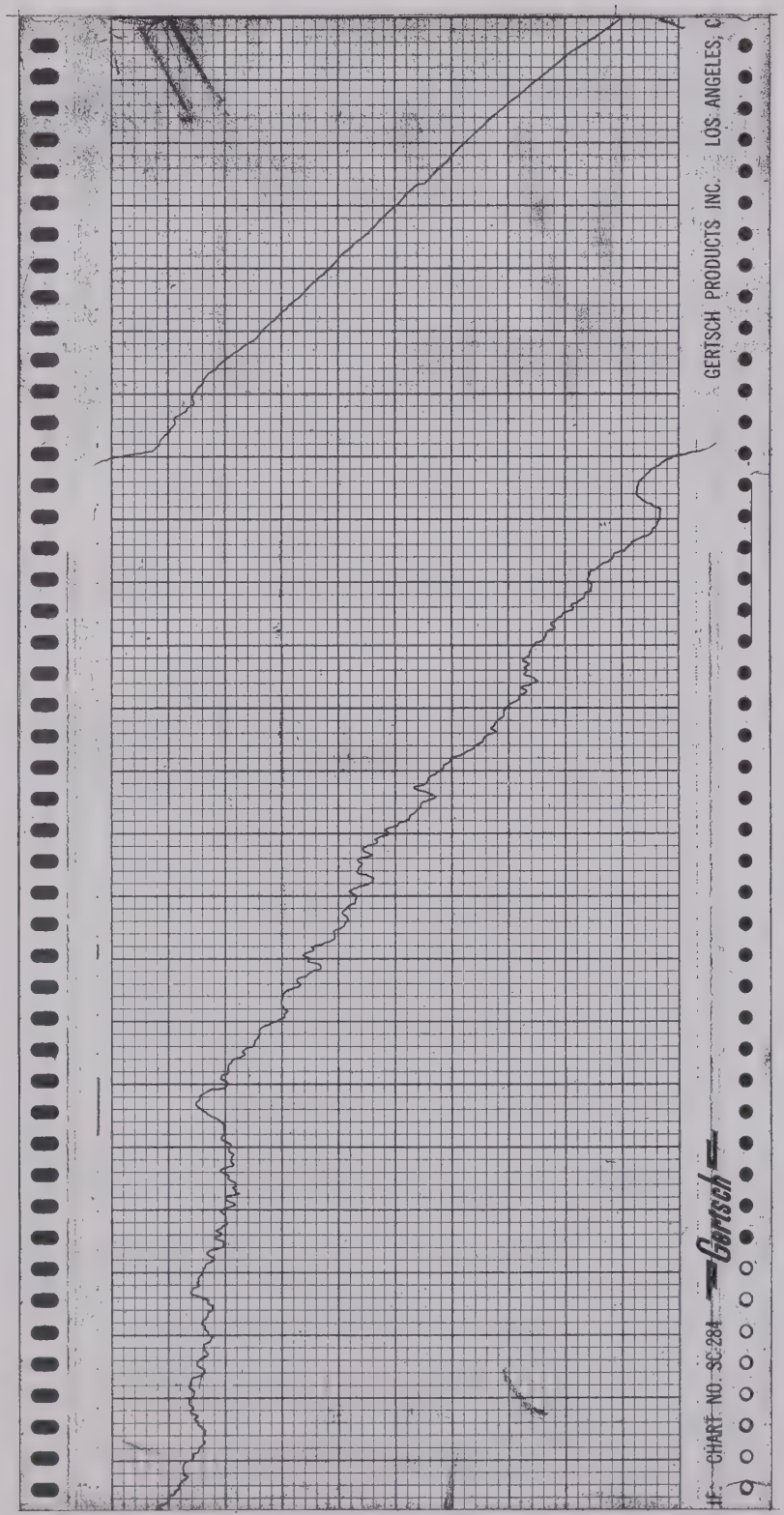
VLF FREQUENCY - 60 KC

CHART SPEED - 4 inches per hour

NOTES:

During this period, the VLF station was temporarily off the air allowing the servo system to drift. This recording shows the typical servo system recovery pattern of overcompensation when the signal returned. Note that the left and right indicator masks are approximately one minor division behind the event on the phase record.

Figure 9-5. Temporary Loss of Signal

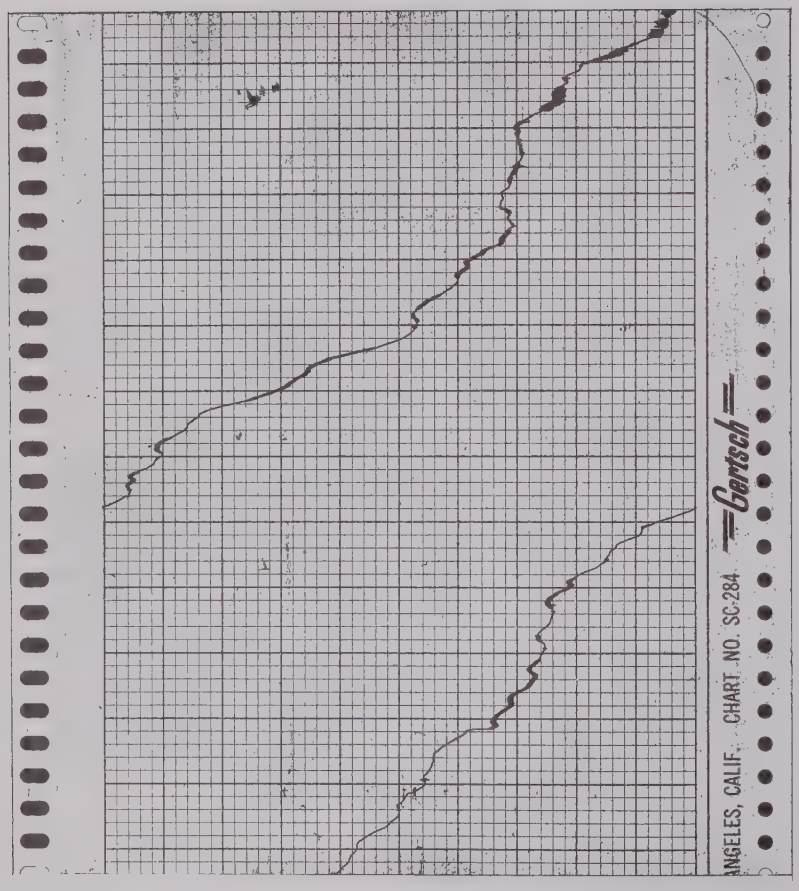


SYSTEM MODE - Receive
SERVO MODE - Auto
SERVO LOCKOUT SWITCH - Auto
VLF FREQUENCY - 60 KC
CHART SPEED - 1 inch per hour

NOTES:

This recording shows the erratic error indication with a perturbed night time signal. At the very end of the perturbed period, the diurnal shift occurred and then the day time recording was smooth and consistent. The average error indication was, however, the same for both night and day. Note the frequent occurrence of indicator masks on the right margin showing brief periods of servo operation at high speed.

Figure 9-6. Perturbed Signal



SYSTEM MODE - Receive

SERVO MODE - Fast

SERVO LOCKOUT SWITCH - Auto

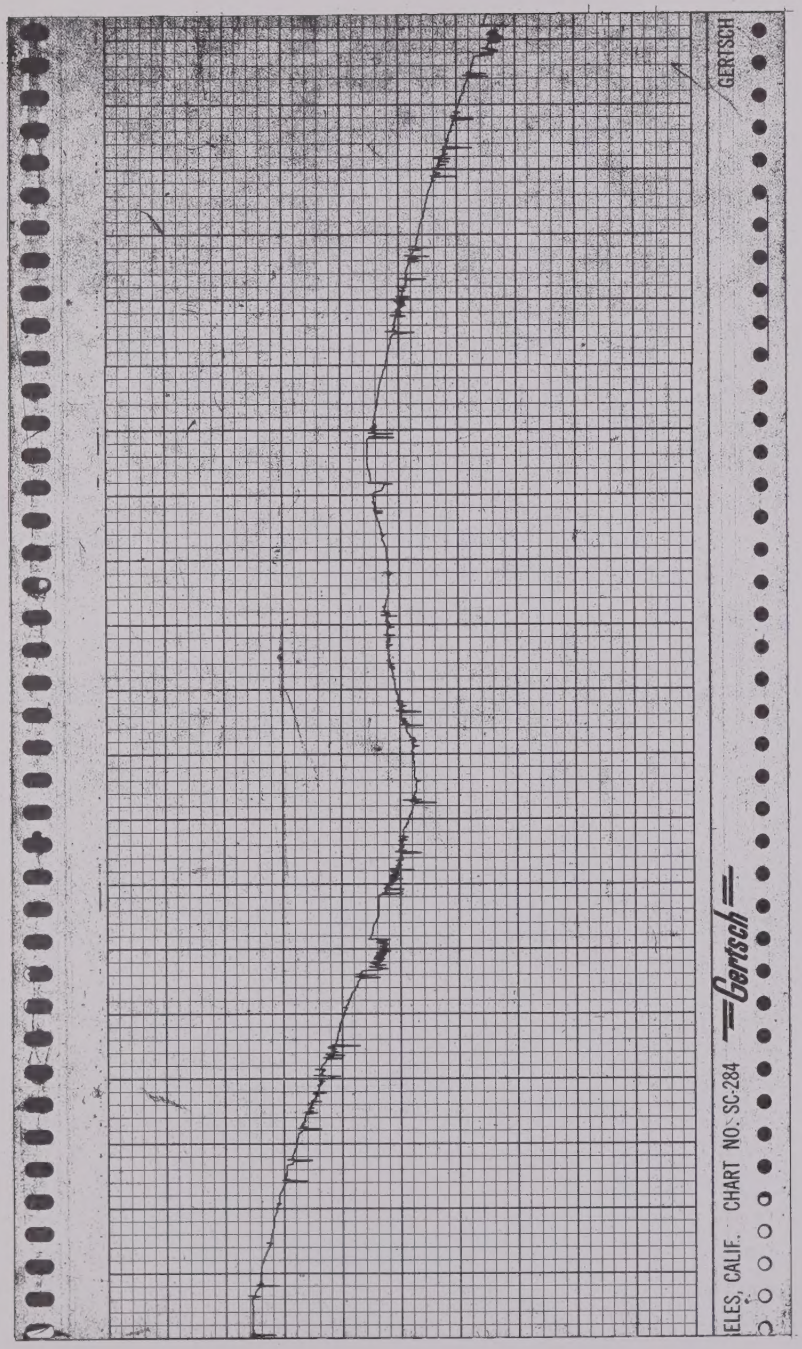
VLF FREQUENCY 60 KC

CHART SPEED - 4 inches per hour

NOTES:

The error indication for a low class oscillator is erratic, reflecting the drift of the oscillator. This particular recording shows the drift in frequency as the crystal oven cycles.

Figure 9-7. Comparison of Low Class Oscillator



SYSTEM MODE - Receive
SERVO MODE - Auto
SERVO LOCKOUT SWITCH - Auto
VLF FREQUENCY - 18.6 KC
CHART SPEED - 4 inches per hour

NOTES:

This recording shows a typical diurnal shift during a period of fair reception. The recording also indicates unbalance in the servo system resulting in excessive drift in one direction.

Figure 9-8. Diurnal Shift